ACOUSTIC TECHNOLOGY COURSE

ENVIRONMENTAL ACOUSTICS TECHNOLOGY III

1978

Ontario

Ministry
of the
Environment

The Honourable
Harry C. Parrott, D.D.S.,
Minister

K.H. Sharpe,
Deputy Minister

ENVIRONMENTAL ACOUSTICS

TECHNOLOGY III

1978

Training and Certification Section
Pollution Control Planning Branch
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Toronto, Ontario M4V 1P5

THIS TRAINING MANUAL HAS BEEN PREPARED BY
THE ONTARIO MINISTRY OF THE ENVIRONMENT
TO COMPLEMENT THE PUBLICATION OF THE MODEL
MUNICIPAL NOISE CONTROL BY-LAW, SEPTEMBER 1978

1st PRINTING: February 1976

2nd PRINTING: September 1978

Copies may be purchased at:

Ontario Government Bookstore
880 Bay Street
Toronto, Ontario M7A 1N8

Copies may be purchased by writing to:

Publications Centre
880 Bay Street
Toronto, Ontario. M7A 1N8

This certification course is one of a series of courses, seminars and workshops regularly offered by the Ontario Ministry of the Environment, Training and Certification Section, in Toronto.

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A C K N O W L E D G E M E N T

The Noise Pollution Control Section, Pollution Control Branch, Ontario Ministry of the Environment, is entirely responsible for the scope, format and development of the course material contained herein:

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The Ontario Ministry of the Environment acknowledges the use of material from the following sources in preparation of this training manual.

Uher Werke
Bruel & Kjaer
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GENERAL INFORMATION

Identifying a lecture period

Each topic will be assigned to a part of a course identified by a three letter number

The first letter indicates which of the three courses the topic is covered under. The three courses are as follows:

Environmental Acoustics I

Environmental Acoustics II

Environmental Acoustics III

The second letter signifies the work-day of the course. Each course lasts 5 days, thus numbers range between 1 and 5.

The third letter indicates the time during the day as codded below:

A: first morning session

B: second morning session

C: first afternoon session

D: second afternoon session

Example:

The lecture period II.3.D. is in the Environmental Acoustics II course, on the 3rd day, in the second afternoon session.

Evening tutorial sessions arranged as required.

SUBJECT:

ENVIRONMENTAL ACOUSTICS - III

TOPIC: III.1.A.& B. (Review)

OBJECTIVES:

Trainee will be able to:

1. Clarify and improve upon his understanding of the course material covered during Environmental Acoustics Technology - I and II, to be accomplished through revision of previous work.

OBJECTIVES:

Trainee will be able to:

1. Describe the variation of typical outdoor community noise with time;
2. Understand the limitations of a sound level meter for measuring community noise;
3. Use a sound level meter to obtain a series of community noise measurements;
4. Understand the concept of Statistical Distribution;
5. Obtain a cumulative distribution from a statistical distribution;
6. Use statistical distribution graph paper.

III.1.C.1. THE VARIATION OF TYPICAL OUTDOOR COMMUNITY NOISE WITH TIME:

In relatively few cases is the noise level of a community constant with time, or steady. In most cases the noise varies continuously and often between wide limits. The variation of sound level is built up from all of the sources present in that community depending on the level and duration of each source.

Some typical community noises are listed below:

1. Vehicle noise. There is increased activity with the morning and evening rush-hour on weekdays. When one is close to highways, one senses the noise of individual vehicles; when one is distant, the noise is more the roar of traffic in general.

2. Other transportation. Other transportation sources have their own time-dependence. The "pass-bys" of both aircraft and trains are seldom so frequent that their noises merge into one; consequently, if one hears a particular aircraft or train, there is as a distinct noise intrusion (over and above any other noise) lasting from a few seconds to, at most, a couple of minutes.

3. Industrial and commercial activities. Generally these occur over the time we call the working day. There may be accompanying vehicle noise associated with shipments. Except when night-shifts are being worked, the noise at night is usually confined to a few sources to do with the upkeep of the premises.

4. Construction. More often than not the noise varies from minute to minute, as different operations occur, and from day to day or week to week as the construction project moves to completion.

5. Residential noise. The noise may be more intrusive on weekends, and on weekdays in the evenings, than it is at any other time. Sources are numerous and range from lawn-mowers to late-night parties, from power-saws to dog barks, from air-conditioners to swimming pool plunges.

In any typical community, the lower noise levels will be present for a major portion of the time and will consist of natural sounds such as leaves rustling, flowing water, bird or animal noises. These noises are often accompanied, or perhaps dominated, by distant traffic noise or steady industrial noise. The next higher noise levels will be present for less time and be composed of such sources as nearby highways. Increasing again in level, and decreasing in duration, local traffic would contribute next to the sound pattern. Trucks and trains could give higher levels but are only present for short periods of time. Sources giving even higher levels are children shouting, dogs barking and even lightning, all of which are fortunately only present for very short periods of time. It is, of course, difficult to generalise the sound level variation with time in a community, but it can be judged from the example given that, as the sound level increases, then it is present for shorter periods of time. This trade-off of level and time duration is generally typical of most community noise situations.

Range of Variation in Community Noise Levels:

To give some idea of the possible variation of community noise levels consider the two extreme situations; in the first case the community is located adjacent to a busy freeway and at all times the noise climate is dominated by the free flowing traffic noises. Typical variation in the community is 10 to 20 dB. On the other extreme consider the situation of a community situated close to railway tracks. At night with no trains on the tracks the noise level in the community will be very low, typically 25 to 30 dBA in quiet surroundings. However, as a train passes by the noise levels could increase to some 90 dBA. This gives a sound level range of some 60 dBA. Clearly if measurements are required over this wide range then specialized instrumentation may be required.

III.1.C.2. THE LIMITATIONS OF THE SOUND LEVEL METER FOR COMMUNITY NOISE MEASUREMENT:

It has been stated in a previous course of this series that if a sound level meter needle shows a range of deflection greater than 3 dBA then a single,eye-average,sound level will not accurately reflect the noise environment and should not be taken. Clearly many community noise situations will produce (even on "Slow") deflection ranges greater than 3 dBA, making the sound level meter unsuitable for community noise measurement.

A further problem may occur because of the limited scale range of normal sound level meters. At most a 15-20 dBA range is provided for sound level indication without the necessity of changing attenuators. Thus even if a single sound level could reflect the community noise situation, or if a system were devised for using a sound level meter to measure noise, then only sound level variations over this 15 to 20 dBA range could be analysed. In fact, a sound level meter can be used for community noise analysis but the limited scale range does restrict the use of the instrument.

III.1.C.3. USING A SOUND LEVEL METER TO OBTAIN A SERIES OF COMMUNITY NOISE MEASUREMENTS:

How can the simple sound level meter be used to give an assessment of non-steady community noise? The answer is by taking single sound level measurements at regular intervals (say 10, 20 or 30 seconds) over a specified measurement duration. Imagine that a sound level meter was used close to a busy highway, where the variation is only 10-20 dB. Noise levels were taken at exactly 10 sec. intervals for 10 minutes, making 60 single sound level measurements altogether. The results were taken to the nearest dBA, and entered into the following chart in Figure III.1.C.1, each asterisk representing one sound level reading.

The chart provides a useful description of all the variation of the noise level over the five minute period. The noise level never fell below 65 dBA. The noise level stayed for a long time at 70 dBA, this level probably being associated with individual car pass-bys.

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64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80
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Figure III.1.C.1: A Typical Histogram of Sound Level Measurements Adjacent to A Freeway

A second peak occurred at a sound level of 75 dBA which probably represented individual truck pass-bys, which would be less frequent than the cars, but at a higher noise level. The maximum sound level recorded was 78 dBA. Thus the chart provided a useful picture of the noise variation over the ten minute period. Such a chart is known as a HISTOGRAM, and is a diagrammatic representation of the STATISTICAL DISTRIBUTION of the sound variation during the ten minute measurement period.

In using a sound level meter to measure community noise the following cautions should be taken:

(a) The measurements should not be tried if short duration noises are present.

(b) The meter must be read at the precise instant regularly.

(c) The period of measurement should be long enough to adequately represent the noise climate.

III.1.C.4. THE STATISTICAL DISTRIBUTION:

We have already seen how a time-varying sound level can be described in chart form which indicates for how long the sound remained at a certain level. This method of describing the sound level variation is known as the statistical distribution. In general, however, there are differences to the particular case we have discussed. First of all,the sound varied over only 14 dBA whereas the community noise level in many cases will vary over a greater range than this. Taking the readings every dBA for wide ranging noise levels results in too large a set of numbers. To avoid this problem, the sound levels are grouped together in certain dBA windows. Typically these windows are up to 5 dBA in width.

A second difference is that very often we have very much more than 60 readings, perhaps as many as 10,000. These large numbers can be cumbersome. To avoid this difficulty,the number of times the sound was in a certain dBA window is divided by the total number of counts and multiplied by 100 to give a percentage of of total number of counts. Thus the statistical distribution is usually stated as the percentage of the measurement time for which the sound level remained in each of the dBA windows of interest. In all cases in the analysis of community noise levels, the dBA windows are constant across the sound level range. Very often 5 dBA wide windows are used, a total sound level range of 50 dBA being divided into 10 windows. An example of such a statistical distribution is shown in Figure III.1.C.2.

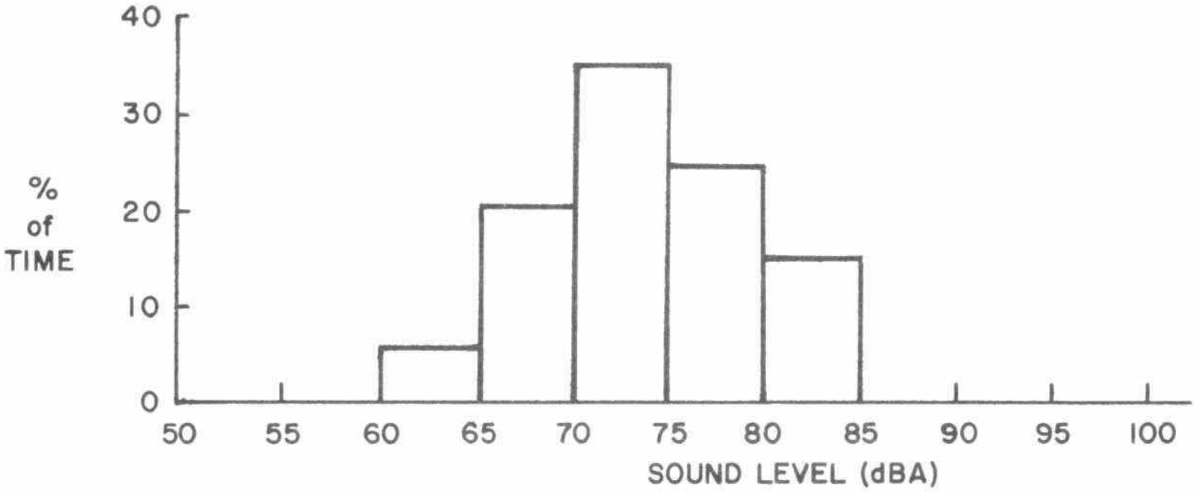


Figure III.1.C.2: A Typical Statistical Distribution Plot

In tabular form, this statistical distribution would appear as follows:

Sound Level Range (dBA)	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100
% of time	0	0	5	20	35	25	15	0	0	0

It should always be checked that the individual percentages add up to 100% as they do in this case.

III.1.C.5. THE CUMULATIVE DISTRIBUTION:

Useful though the statistical distribution is as a means of presenting time-varying sound data it still does not present information in the most convenient form for further consideration or annoyance assessment. The statistical distribution answers the question "for what percentage of the time was the noise level

within a certain dBA range?" The cumulative distribution, however, answers the question "for what percentage of the time was a certain noise level exceeded?"

How can the cumulative distribution be derived from the statistical distribution? The best way to do this is by a step by step procedure. By way of example, consider the problem given in Figure III.1.C.2. Starting at the right hand side of the graph, we ask for what percentage of the time was the level over 85 dBA. The answer is of course 0%. This gives us the first point of the cumulative distribution: 85 dBA, percent of time exceeded is 0%.
We ask the question again - for what percentage of time was the level of 80 dBA exceeded? Again looking at the diagram, the answer is 15% of the time. Now we have two points on the cumulative distribution:

85 dBA, percent of time exceeded is 0%

80 dBA, percent of time exceeded is 15%

Continuing with the procedure, the sound level of 75 dBA was exceeded 25 + 15 or 40% of the time giving a third point on the curve. If we continue with this procedure, adding a further dBA range each time we would eventually ask the question: for what percentage of the time was 60 dBA exceeded? Adding in the final 5% would give the answer 100% of the time or of course the level was never below 60 dBA. For comparison both the statistical and cumulative distributions are plotted out in Figure III.1.C.3. with the tabular form of both listed below.

STATISTICAL DISTRIBUTION OF NOISE CLIMATE

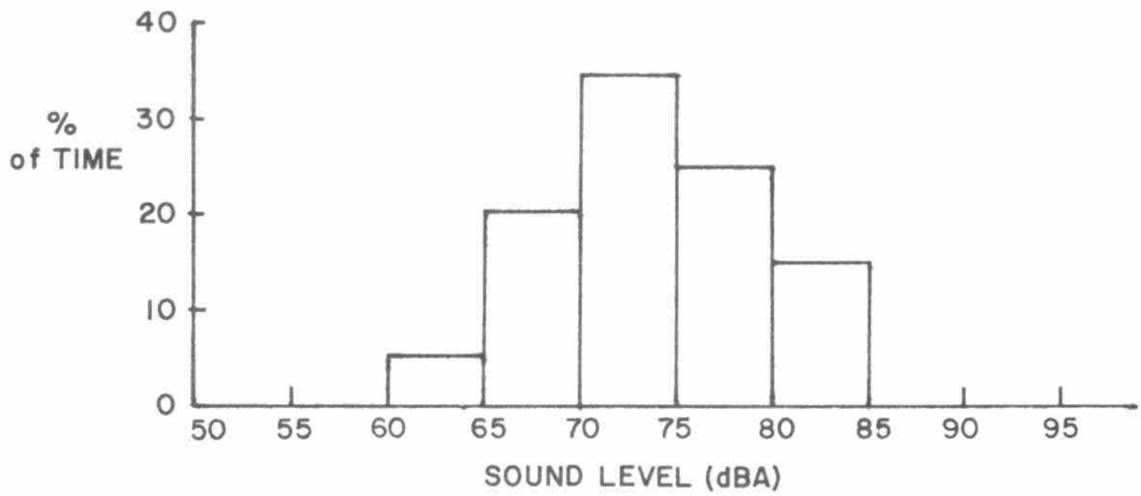
Sound Level Range (dBA)	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100
% of time	0	0	5	20	35	25	15	0	0	0

CUMULATIVE DISTRIBUTION OF NOISE CLIMATE

Sound Level dBA	50	55	60	65	70	75	80	85	90	95
% of time exceeded	100	100	100	95	75	40	15	0	0	0

Table 1: Statistical and Cumulative Distribution Levels in dBA For Freeway Sound Measurements

STATISTICAL DISTRIBUTION



CUMULATIVE DISTRIBUTION

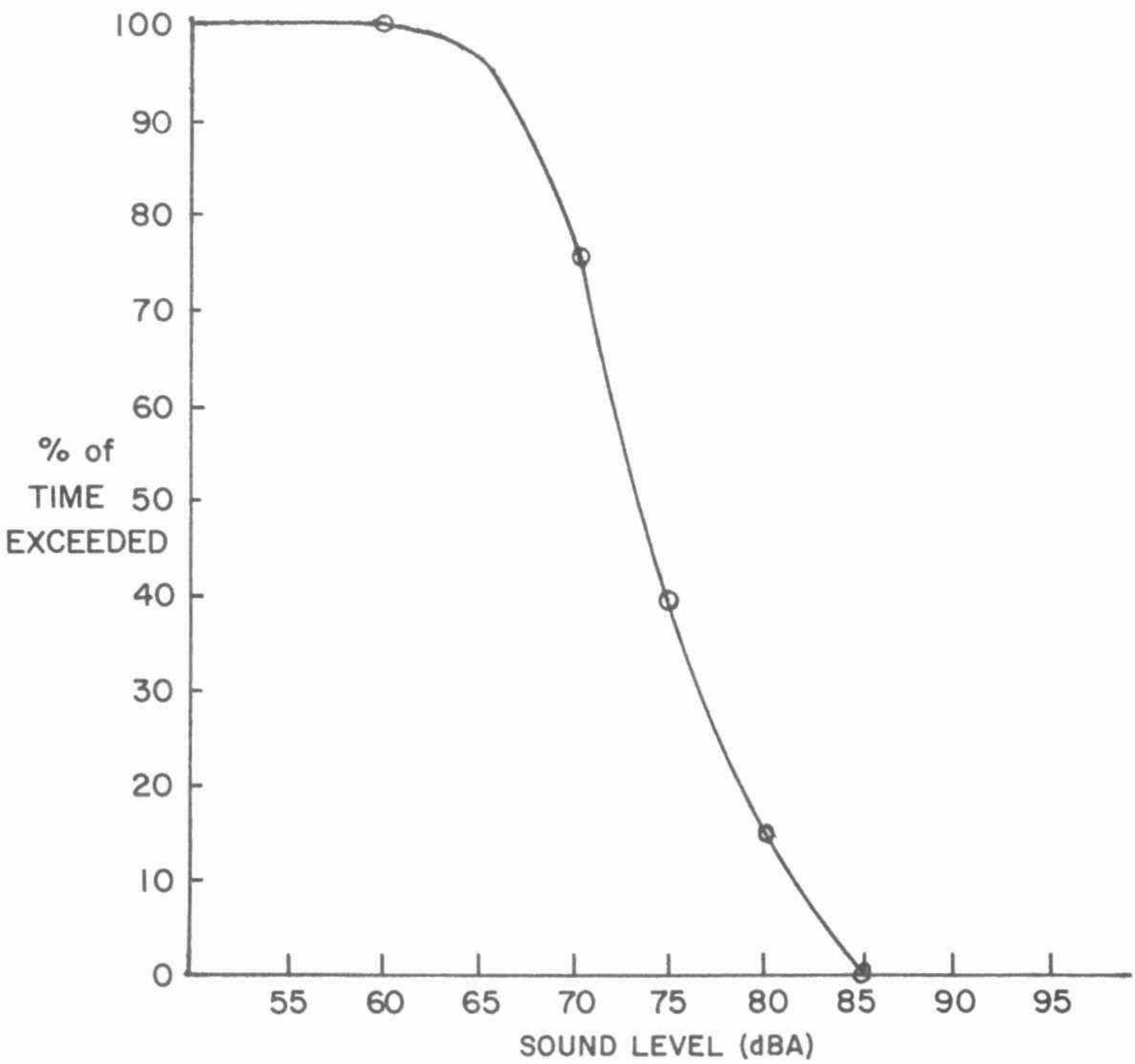


Figure III · 1 · C · 3: Generation of Cumulative Distribution Plot From Statistical Distribution Plot

III.1.C.6. <u>THE USE OF STATISTICAL DISTRIBUTION PAPER</u>:

The cumulative distribution shown in Figure III.1.C.3. is plotted on a linear percentage scale. A special graph paper (known as statistical distribution paper) exists for plotting such distribution. It has a non-linear percentage scale and is shown in Figure III.1.C.4. The same cumulative distribution has been plotted on this special paper. Notice first of all the re-orientation of the scales and also the strangely non-linear percentage scale.

Why is this percentage scale used? There is a certain statistical distribution known as "Gaussian" or "Normal Distribution". This distribution is well defined theoretically and often many community noise variations result in a Gaussian distribution. If a statistical distribution is in fact Gaussian then several simplified calculation formulae may be used. Statistical Distribution paper has a % of time exceeded scale so arranged that if a <u>Gaussian Distribution</u> were plotted on it, then <u>a straight line would result</u>. The statistical distribution shown in Figure III.1.C.3. has also been plotted on the statistical distribution graph paper. It can be seen that in the <u>middle of the paper the graph is approximately a straight line</u>, and <u>could probably be considered as being Gaussian</u>. Thus simplified calculation methods (e.g. the one covered later in the topic III.1.D.) applying to Gaussian distributions could be used for this distribution.

Statistical distribution paper has the second advantage of spreading out the portion of the cumulative distribution above the 10% exceeded point. This is an important region in acoustics, as will be shown later and can be more easily examined using this paper.

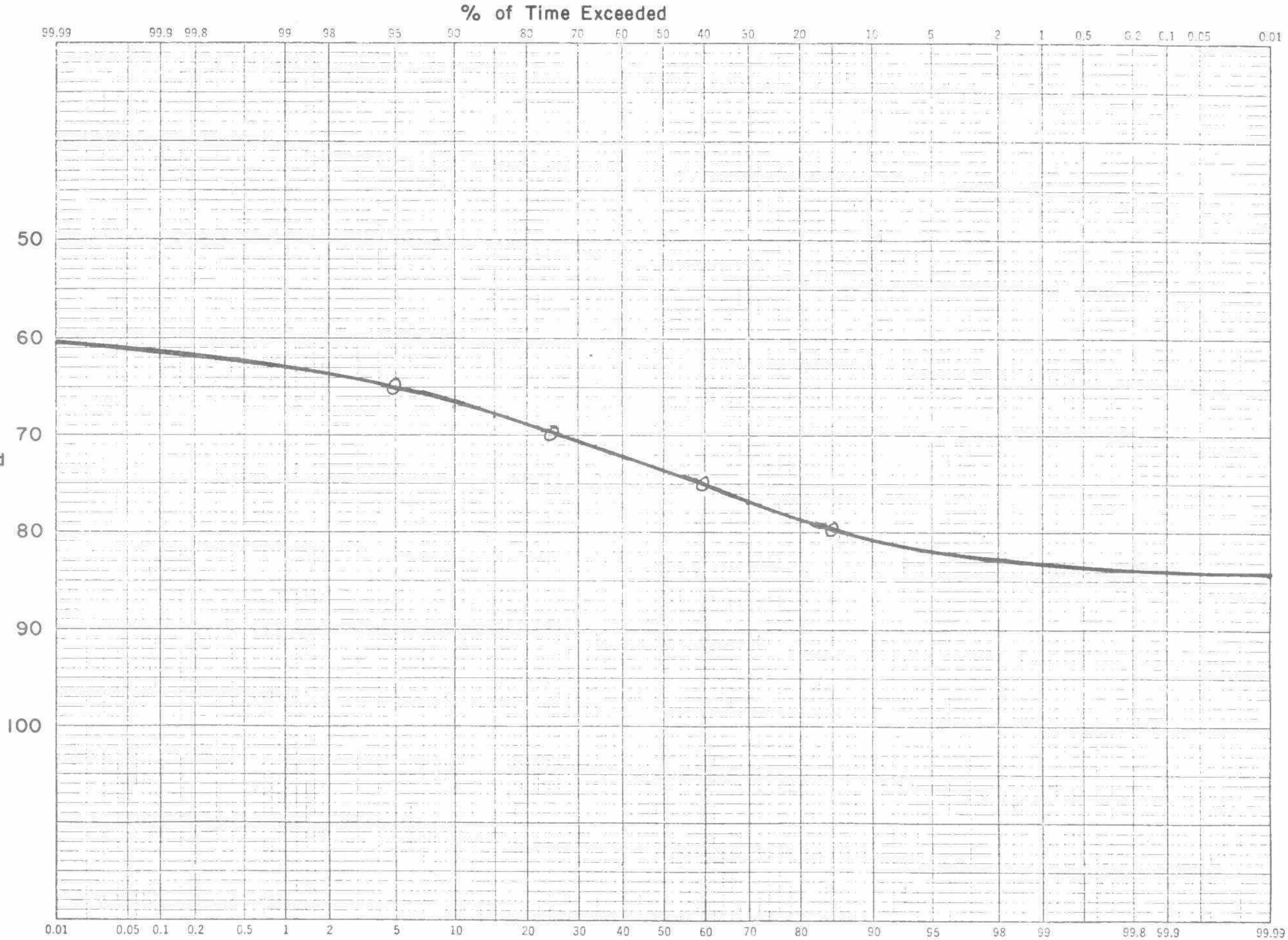


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Figure III·1·C·4: Cumulative Distribution Plotted on Probability Graph Paper

SUBJECT:

ENVIRONMENTAL ACOUSTICS - III

TOPIC: III.1.D (Acoustics)

OBJECTIVES:

Trainee will be able to:

1. Define L_N, L_{100}, L_{90}, L_{50}, L_{10} and L_1;
2. Use statistical distribution paper to obtain L_{90}, L_{50}, L_{10} and L_1;
3. Calculate L_{eq} from L_{50} and L_{10} for Gaussian noise;
4. Discuss the usefulness of L_{eq} versus L_{90}, L_{50}, L_{10} and L_1 as community noise descriptors;
5. Discuss the importance of measurement duration in community noise measurements.

III.1.D.1. L_N, L_{100}, L_{90}, L_{50}, L_{10} and L_1:

We have seen in the topic III.1.C. that a cumulative distribution is a plot of the percentage of time for which certain sound levels were exceeded. In order to extract useful information from the plot, very often the reverse question "what level was exceeded for a certain percentage of the time?" is presented. For instance, it may be required to know from the cumulative distribution (Figure III.1.D.1) which we are considering, what level was exceeded for 10% of the time? Looking at the plot on statistical distribution paper, we see that the level exceeded for 10% of the time was 81 dBA. Such levels are often known as L_N values, L_N being defined as follows:

- L_N is the level exceeded for N% of the time.
  Common L_N values used are as follows;
- L_{100}: the level exceeded for 100 % of the time or the lowest noise level.
- L_{90}: the level exceeded for 90% of the time or the "ambient" noise level.
- L_{50}: the level exceeded for 50% of the time or the "median" noise level.
- L_{10}: the level exceeded for 10% of the time, measures the "average level of intrusive" noises.
- L_1 : the level exceeded for 1% of the time, measures the "highly intrusive" noises.
- L_0 : the level exceeded for 0% of the time or the "highest" noise level (also known as L_{MAX}).

III.1.D.2 L_{90}, L_{50}, L_{10} AND L_1 FROM CUMULATIVE DISTRIBUTION GRAPH:

All these levels have been obtained from the cumulative distribution shown in Figure III.1.D.1.

L_N	Sound Level dBA
L_{100}	60
L_{90}	67
L_{50}	74
L_{10}	81
L_1	84
L_0	85

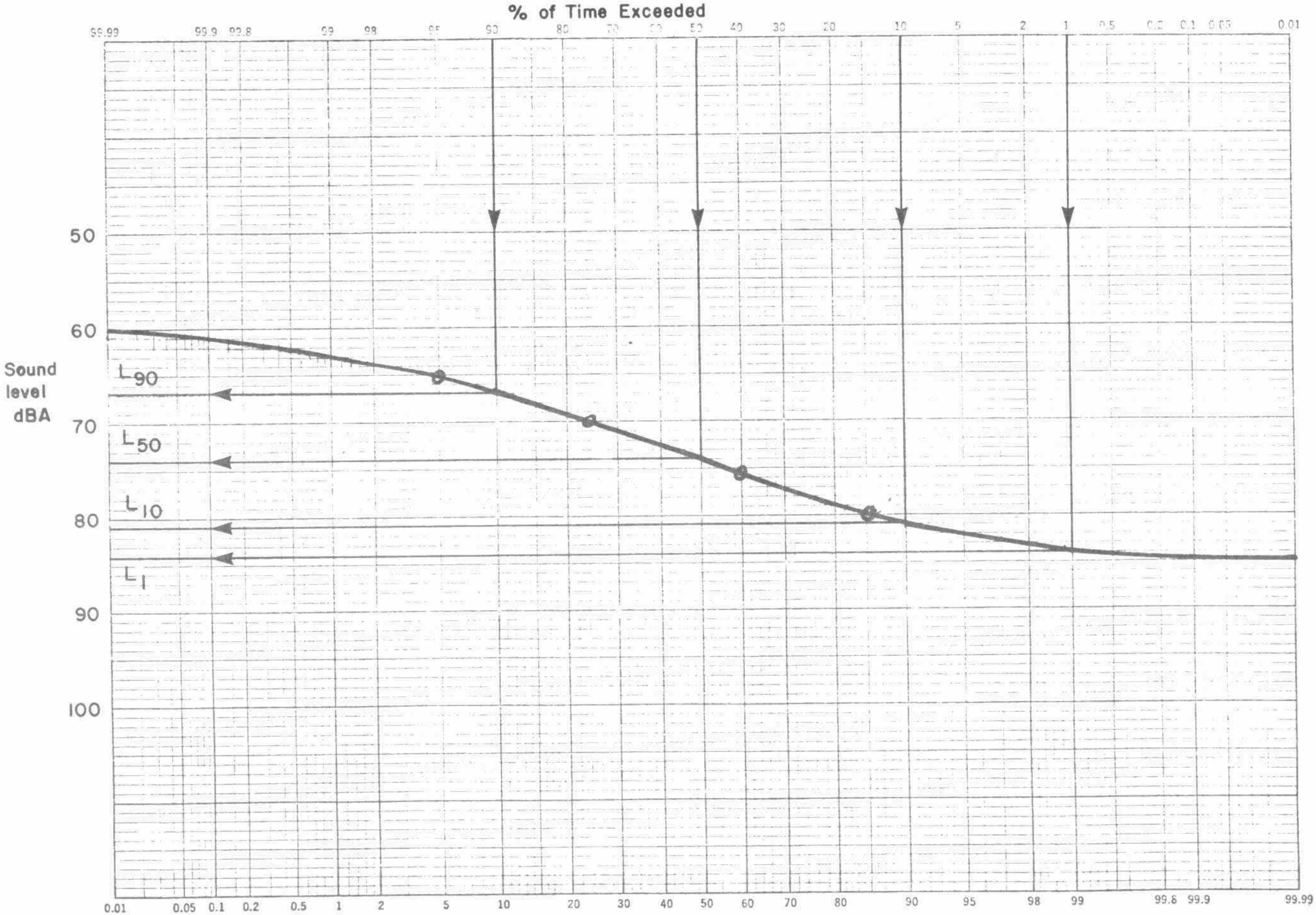


Figure III · I · D · I: A Cumulative Distribution Plot

III.1.D.3 CALCULATION OF L_{eq} FROM L_{50} AND L_{10} (for Gaussian Noise):

It is often required to calculate L_{eq} (the energy equivalent continuous sound level) from L_{50} and L_{10} which can easily be obtained from a cumulative distribution curve. This can be done, but only for a Gaussian distribution, with a cumulative distribution that becomes a straight line when plotted out on statistical distribution paper. The formula is as follows:

$$L_{eq} = L_{50} + 0.07 \quad (L_{10} - L_{50})^2 \qquad \text{...(III.1.D.1)}$$

for Gaussian distribution only.

From the cumulative distribution in Figure III.1.D.1,

$$\begin{aligned} L_{50} &= 74 \text{ dBA} \\ L_{10} &= 81 \text{ dBA} \\ \therefore L_{eq} &= 74 + 0.07 \ (81 - 74)^2 \\ &= 77.4 \\ \therefore L_{eq} &= 77 \text{ dBA} \end{aligned}$$

As a check, L_{eq} was obtained directly from the statistical distribution by the method covered in the topic II.4.A. & B. and found to be 77 dBA. Thus for Gaussian noises, L_{eq} can be simply and accurately found from L_{50} and L_{10}. The formula should NOT be used for non-Gaussian distribution, that is, those which are not closely straight lines when plotted on statistical distribution paper.

III.1.D.4. THE USEFULNESS OF L_{eq} VERSUS L_{90}, L_{50}, L_{10} AND L_1 AS COMMUNITY NOISE DESCRIPTORS:

In the topic II.1.D., L_{eq} was described as being a single number descriptor of time-varying or non-steady noise. Although it has been found to be a good rating scale for the assessment of annoyance due to time-varying noise, it may not apply in some cases. Thus it may be necessary when rating a community noise for annoyance to be more flexible, and consider instead the cumulative distribution in general and several L_N levels (such as L_{90}, L_{50}, L_{10} and L_1) in particular. In this manner the entire variation of the noise over the time period of the measurement can be assessed. It may be thought that taking four L_N parameters may be a heavy-handed approach, but to be more certain of correctly rating the annoyance due to widely differing types of sound variations, such an approach may well be safer.

A second difference between L_{eq} and the cumulative distribution parameters is that L_{eq} emphasises the higher levels and produces dBA values higher

than simply averaging would produce (because it is an energy average and not a simple pressure average). Thus L_{eq} tends to be more representative of the higher noise levels, and is thus a good measure of high level intrusive type noises. However, it often happens that despite the presence of high level intrusions, a moderately high, almost continuous, background level will be the more annoying. In this case L_{eq} would not rate the total noise situation accurately and L_{90} or L_{50} would be a better descriptor. To avoid such rating it is again safest to take the important L_N values (such as L_{90}, L_{50}, L_{10} and L_1) and compare all of these with criteria values.

A further property of L_{eq} is that it responds to changes in the duration or levels of sound levels much more steadily and continuously as compared to the L numbers. This is illustrated below:

EXAMPLE: Consider a noise climate in which continuous levels of 40 and 80 dBA prevail for the following different times;

(a) 85% and 15% time, respectively,
(b) 88% and 12%, respectively,
(c) 91% and 9%, respectively,
(d) 100% and 0, respectively.

The L_{eq} and L_{10} values are computed for all the above cases over the entire interval as listed below:

(a) L_{10} = 80 dBA, L_{eq} = 72 dBA
(b) L_{10} = 80 dBA, L_{eq} = 71 dBA
(c) L_{10} = 40 dBA, L_{eq} = 70 dBA
(d) L_{10} = 40 dBA, L_{eq} = 40 dBA

The change in the values of L_{eq} is noted to be gradual from case (a) to (d) whereas L_{10} changed in a step from 80 to 40 dBA as the noise climate changes. The ability of L_{eq} to reflect changes continuously is an important one and is worthy of consideration when assessing the noise climate in a community.

III.1.D.5. THE IMPORTANCE OF MEASUREMENT DURATION IN COMMUNITY NOISE MEASUREMENTS:

It is very important when taking community noise measurements, to obtain a representative sample. Consider the situation of an industry producing fairly continuous mid-level noise and occasionally performing a venting operation which produces a higher level for a short period of time. In this situation, it would be incorrect to analyse the continuous level on its own without the higher level noise. It would also be incorrect to analyse the high level and ignore the period when the lower continuous level was present. Clearly, in this case, a time period must be analysed which contains both noise situations, and further, does not place unequal weight on either situation. To ensure that a representative sample has, in fact, been taken,a considerable time period may have to be analyzed. In some cases up to several hours or the entire day, evening or night period.

The Model Municipal Noise Control By-law requires that noise levels from non-steady stationary sources be sampled continuously for a minimum of one hour at a point of reception.

SUBJECT:

ENVIRONMENTAL ACOUSTICS - III

TOPIC: III.2.A.& B. (Acoustics)

OBJECTIVES:

Trainee will be able to:

1. Understand the relationship between sound and vibration;
2. Describe the different types of vibration;
3. Describe what is meant by vibratory displacement, velocity and acceleration and understand the relationships between them;
4. Describe an accelerometer and a velocity pick-up.

III.2.A.& B.1. THE RELATIONSHIP BETWEEN SOUND AND VIBRATION:

In many cases sound is produced by a surface moving to and fro, or "vibrating". A typical example of this is a loudspeaker. An electrical signal representing the speech or music to be reproduced is fed to the loudspeaker. The diaphragm of the loudspeaker then oscillates in the same manner as the electrical signal applied to it. This vibration of the loudspeaker diaphragm disturbs the air adjacent to it and produces a sound wave.

Speech is formed in a similar manner. The human vocal chords are set into vibratory motion which again disturbs the air around the chords to produce a sound wave. A violin string produces a musical note in a similar way. Other vibratory sources are metal panels such as motor casings or automobile sides or roofs, the walls, or ceilings of a building shaken by ground vibration,and finally the reed in a clarinet or saxophone. These later examples show that vibration does not always produce noise, but has been employed by man as a source of pleasant musical sound.

The aspect of vibration which is of interest here relates to the complaints about the fear of property damage received from the residents living in the vicinity of punch presses, shear presses, forming presses, drop forges and stone quarries.

Apart from the fear of property damage, the human response to vibration is a further consideration of interest to us, although to a lesser degree. At frequencies below about 1 Hz, motion sickness can occur. In the range of 3 to 6 Hz, the region of lower abdomen is excited by the vibration. The head-neck-shoulder response is in the 20 — 30 Hz range, while the eyeball resonates in the range of 60 to 90 Hz and the lower jaw from 100 to 200 Hz.

III.2.A.& B.2. THE DIFFERENT TYPES OF VIBRATION:

In a similar way to sound, vibration can be classified into the two broad groups of steady and non-steady vibrations.

Steady vibrations, produced for example by rotary motors or engines, do not vary significantly with time and are normally of a sinusoidal nature. Non-steady vibrations do vary with time and can be intermittent, such as train pass-by vibration,or impulsive such as ground vibration due to blasting, seismic work or earthquakes.

III.2.A.& B.3. DISPLACEMENT, VELOCITY AND ACCELERATION:

The terms displacement, velocity and acceleration are readily understood in terms of, for instance a car, truck or train moving in a striaght line. However, these three quantities can also be applied to oscillatory motions such as vibration. Shown in Figure III.2.A.& B.1 is a graph of the variation of position of a particle over a short time period. The motion is sinusoidal which is typical of many steady vibrations. It can be seen that the instantaneous displacement increases initially from zero, reaches a peak, decreases again to zero and increases in the opposite direction. If we wished to describe the magnitude of this vibration, how could it be done? The methods of describing the magnitude of sound waves are also applied to vibration. The peak displacement could be measured and used to describe the oscillation. The peak displacement is often known as the "amplitude" of the vibration. The amplitude is most often defined as being the distance between zero displacement and the peak displacement. However in some cases the "peak to peak" amplitude is often measured. Care should then be taken in quoting and reading peak vibration amplitudes.

An R.M.S. (root mean squared)value of the displacement could also be used as a measure of the magnitude of a vibration. Also shown on Figure III.2.A.& B.1 are the zero to peak, peak to peak and RMS values for the waveform.

A further important parameter of a vibration is the period T as shown in the figure. From the period T the frequency of the wave can be determined as follows:

$$f = \frac{1}{T} \qquad \text{......... (III.2.A.\& B.1.)}$$

The frequency of a vibration is defined in exactly the same way as the frequency of a sound.

By considering the waveform shown in Figure III.2.A.& B.1. we can describe how the velocity of the particle varies with time if we remember that velocity is the rate at which the displacement changes, or the slope of the wave form at any instant. Initially the waveform has its greatest upward slope and thus the velocity against time graph of Figure III.2.A.& B.2 must start at a maximum positive value. The slope of Figure III.2.A.& B.1 then decreases to zero (the waveform having a flat top) and increases again to a maximum downward value, and so on. The full velocity waveform is shown in Figure III.2.A.& B.2, and is of the same shape

Displacement: $x = \sin\theta$

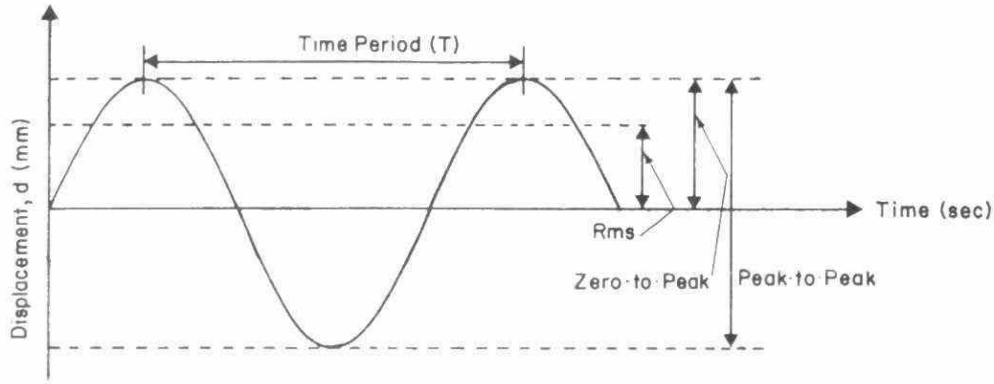


Figure III-2-A & B-1: Vibration Displacement of a Particle Subjected to Steady Oscillatory Motion.

Velocity: $\dot{x} = \cos\theta$

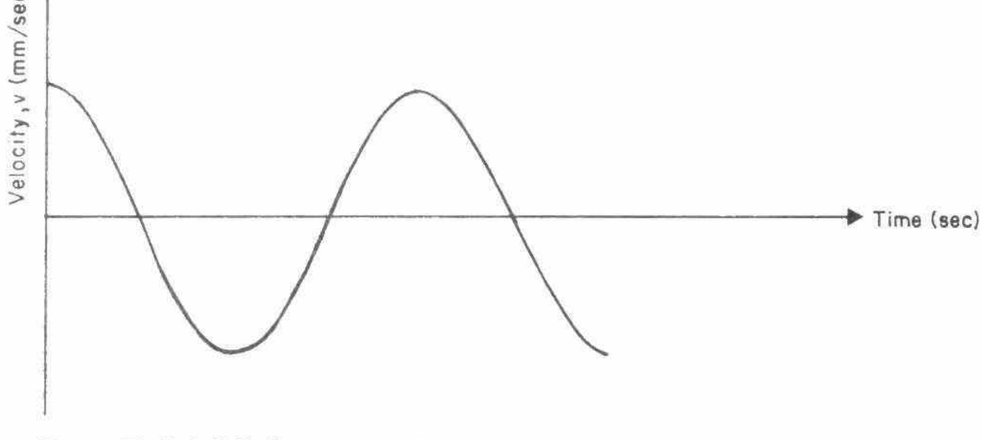


Figure III-2-A & B-2: Velocity of Particle with Time.

Acceleration: $\ddot{x} = -\sin\theta$

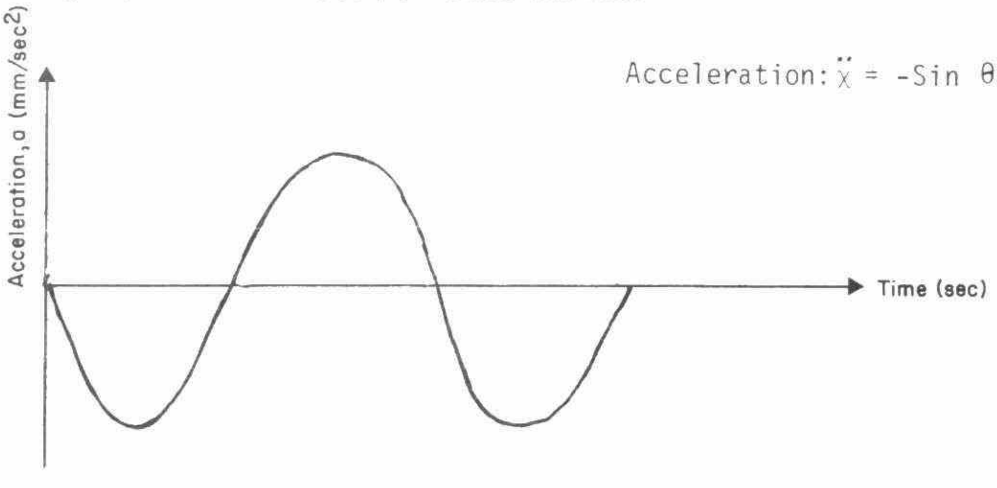


Figure III-2-A & B-3: Acceleration of Particle with Time

as the displacement waveform, except for a shift.

Again, if we remember that acceleration is rate of change of velocity, or the slope of the velocity waveform, we could derive the acceleration waveform from Figure III.2.A.& B.2. The acceleration waveform is shown in Figure III.2.A.& B.3. Again, it is the same shape as the velocity waveform, but shifted.

We need to know what quantities to use for displacement, velocity and acceleration before we can measure them or convert from one to the other. Again, normal units can be used for these quantities as are used for motion in a straight line. These quantities are shown below:

DISPLACEMENT	(d)	-	millimetres (mm)
VELOCITY	(v)	-	millimetres/second (mm/sec)
ACCELERATION	(a)	-	millimetres/second.second (mm/sec^2)

It is often a standard practice to specify acceleration in terms of the acceleration due to gravity, g (which in metric units is 9810 mm/sec^2). The acceleration is then expressed as so many "g". The calculation would be as follows:

$$\text{acceleration (g)} = \frac{\text{acceleration } (mm/sec^2)}{9810} \quad \ldots (III.2.A.\&\ B.2)$$

III.2.A.& B.4. THE RELATIONSHIPS BETWEEN DISPLACEMENT, VELOCITY AND ACCELERATION:

We have already learnt that velocity is the rate of change (or slope) of displacement and acceleration is the rate of change (or slope) of velocity. The process of finding rates of change is known mathematically as differentiation. By differentiation it is possible to determine the velocity (v) from the displacement (d), and the acceleration (a) from the velocity (v). It turns out that a very important parameter in this conversion is the frequency (f) of the waveform. The relationships are as follows:

$$v = d.2\pi f \quad \ldots (III.2.A.\&\ B.3.)$$

$$\text{and } a = v.2\pi f \quad \ldots. (III.2.A.\&\ B.4.)$$

$$\text{also } a = d.(2\pi f)^2 \quad \ldots. (III.2.A.\&\ B.5.)$$

These relationships apply only for sinusoidal type vibrations as shown in Figures III.2.A.& B.1., III.2.A.& B.2., and III.2.A.& B.3.
A further point is that if a peak displacement is converted, a peak velocity results. If an RMS displacement is converted, an RMS velocity

results. The formula of use in conversion from peak to RMS is,

$$RMS = 0.707 \times PEAK \quad \ldots\ldots \quad (III.2.A.\&\ B.6)$$

Again, this relationship is only true for sinusoidal type of vibrations.

III.2.A.& B.5. ACCELEROMETER AND VELOCITY PICK-UP:

As its name implies an accelerometer measures the acceleration in either mm/sec^2 or "g" units. Many accelerometers operate using piezoelectric material as do piezoelectric microphones. Such materials when subjected to a force, produce an electrical voltage proportional to that force. The piezoelectric material, in the form of a cylindrical slab is cemented between the base of the accelerometer and a mass (such as a metal cylinder). When the accelerometer is attached to a vibrating surface it is sandwiched between the surface and the mass which exert a force on the piezoelectric material. The voltage so produced is proportional to the acceleration of the vibrating surface.

Accelerometers have the advantage of being small and lightweight, need no external voltage supply and have good high frequency response. They have the disadvantage of requiring a preamplifier to suitably condition their output (as do microphones). A typical frequency response curve of an accelerometer is shown in Figure III.2.A.& B.4.

A velocity pick-up, when placed on a vibrating surface responds to the velocity of the surface. A velocity pick-up contains a metal mass held in place by springs. This metallic mass which vibrates in sympathy with the vibrating surface is also a permanent magnet which excites a voltage in a stationary coil placed near to it. The velocity pick-up has the advantage of not requiring preamplification. However, it has the disadvantages of being much larger than an accelerometer, having a limited frequency range, being moderately fragile and sensitive to extraneous magnetic fields.

Although both the velocity pick-up and accelerometer are useful for acoustic work, the accelerometer is perhaps more versatile. If velocity or displacement is required rather than acceleration it can be obtained knowing the vibration frequency, or very often the conversion to velocity and displacement from acceleration is done electronically so that an accelerometer can easily be used for velocity measurements.

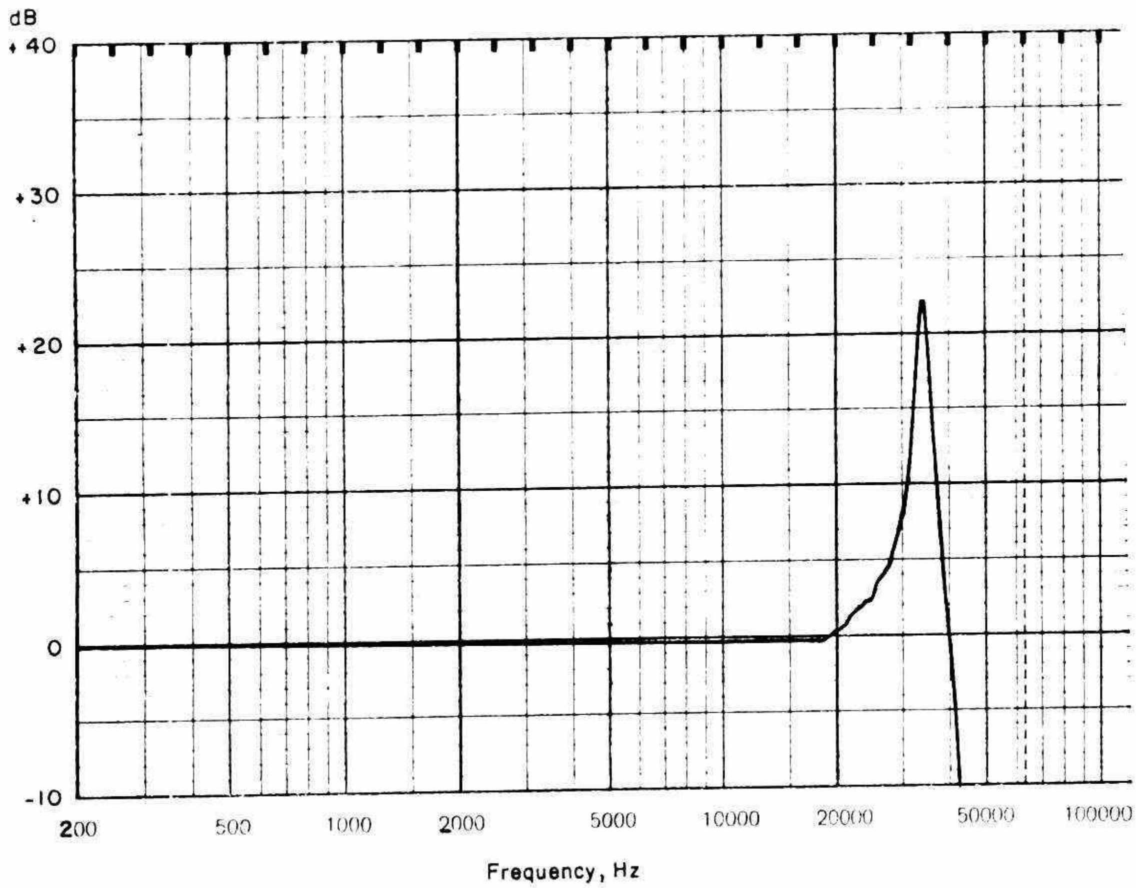


Figure III·2·A & B·4: A Typical Frequency Response Curve of B & K Type 4339 Accelerometer

OBJECTIVES:

Trainee will be able to:

1. Understand the evolution of Environmental Law;
2. Understand the constitutional aspects of noise control legislation;
3. Understand the importance of case law in setting legal precedents;
4. Appreciate the process of issuing a Control Order;
5. Prepare for Counsel the documentation required for a prosecution using a Municipal Noise Control By-law.

III.2.C.1.

LEGAL ASPECTS-EVOLUTION OF ENVIRONMENTAL LAW:

Environmental law, as we now know it, evolved from the common law of nuisance. The common law is an unwritten body of law, developed over the centuries by judges hearing the claims of competing litigants. Thus, common law is the record of their decisions and is not set out in codes or statutes or text books in individual cases.

The common law of nuisance had 2 branches: private and public nuisance. Private nuisance was a civil wrong. Where a person wrongfully caused or permitted a harmful thing such as noise, vibration, heat, smoke or smell to escape from his land onto the land of another person, thereby disturbing him in the enjoyment of his land, then he could be restrained from continuing to do so by injunction, or required to pay damages, or both.

Public nuisance was a criminal offence. It differed from private nuisance in that the nuisance had to be so widespread in its range or indiscriminate in its effect as to materially affect the reasonable comfort and convenience of a class of the public - for instance, noise emissions from a particular industry impacting on an adjacent residential community.

In Canada, in 1897, the common law of public nuisance was codified in the predecessor to Section 176 of the Criminal Code.

As knowledge of the harmful effects of pollution grew and became widespread and as people's expectations in relation to health, comfort and aesthetic values grew, it was recognized that the common law could be relied on as a suitable instrument for controlling the emission of contaminants into the natural environment.

The civil law was little used because most people lacked the necessary financial and intellectual resources.

to pursue their rights and because polluting industries often constituted the economic basis of their own communities.

The Criminal law presented difficulty because of the necessity, in all cases, to prove criminal intent and also because community consciousness had still not developed to the point of recognizing pollution as a crime. In addition, the common law could shut down an industry; require it to pay damages; a fine; or even imprison an offender but it could not require anyone to take positive steps to abate an emission.

The Municipal Act was promulgated to authorize a municipality to pass a by-law prohibiting or regulating the emission of unusual noise or noise likely to disturb the inhabitants. In fact, in modern terms, the Act severely limits municipal power to effectively enforce noise control in the community.

Im 1958, The Air Pollution Control Act was passed. This Act authorized municipalities to pass by-laws for prohibiting or regulating the emission of air contaminants from any source.

In 1967, The Air Pollution Control Act transferred responsibility for air pollution from municipalities to the province. In 1971 this Act was repealed and re-enacted as part of The Environmental Protection Act, 1971 and sound and vibration were classified as contaminants under the Act.

An amendment to The Environmental Protection Act, in 1975, now permits municipalities to enact a noise by-law under the Act. Thus, in any municipality, two noise by-laws may exist concurrently, one under the power of The Municipal Act and the other under The Environmental Protection Act.

III.2.C.2.

CONSTITUTIONAL ASPECTS OF NOISE CONTROL LEGISLATION:

Canada, unlike the United States and many other countries, does not have its constitution embodied in a single document. The Canadian constitution is to be found in a series of Acts passed by the British Parliament, certain traditions and practices that have been followed over the years and the interpretation placed by the courts upon the various constitutional statutes.

Because Canada is a federal state, legislative power has been divided between the federal government and the provincial government . Fortunately, a list of classes of topics in relation to which each government may legislate has been set forth in the British North America Act, 1867. Unfortunately, because some of the classes are so vague and general, it is often not clear whether a particular enactment falls within federal or provincial jurisdiction.

This problem has arisen in respect of The Environmental Protection Act, 1971. In R. V. Lake Ontario Cement Limited (1973) 11 CCC 141, the defendant was charged with emitting the contaminant, noise, into the natural environment impairing its quality for recreational use, contrary to Section 14 (1) (a) of The Environmental Protection Act, 1971.

Section 91 of The British North America Act assigns power to make laws for the peace, order and good government of Canada. Criminal law is assigned exclusively to the federal government.

Section 92 of The British North America Act assigns power to make laws in relation to property and civil rights, as well as local matters, exclusively to the provincial governments. Provincial governments in turn, may delegate certain of these powers to local governments.

In the Lake Ontario Cement case, it was argued that legislation in relation to pollution is a matter of national concern and, therefore, falls within the exclusive jurisdiction of the federal government to make laws for the peace, order and good government of Canada. It was also argued that Section 14 is really criminal law and in conflict with the nuisance provisions of Section 176 of the Criminal Code and, therefore, within the exclusive jurisdiction of the federal government.

The Appeal Court held that the matters dealt with by Section 14 of The Environmental Protection Act, 1971 were property and civil rights, local and provincial, and fell within the classes of topics assigned exclusively to the provinces and Section 92 of The British North America Act. Therefore, Section 14 of The British North America Act. Therefore, Section 14 of The Environmental Protection Act, 1971 was constitutional and environmental concerns were purely provincial in jurisdiction.

III.2.C.3. <u>CASE LAW:</u>

In the introductory material it was pointed out that modern environmental law evolved from the common law of nuisance, a body of law that was literally made by judges. Modern environmental law has been made by the legislature. But because many words and expressions in the English language are ambiguous or imprecise, and because it is difficult when framing legislation to foresee its application to all possible circumstances, problems arise with respect to its interpretation. So the courts have a vital role to play in lawmaking.

One English judge had this to say in 1890, and it is still true in Ontario today:

> "From which cause it appears that the sages of the law heretofore have construed statutes quite contrary to the letter in some appearance, and those statutes which comprehended all things in the letter, they have expounded to extend but to some things, and those which generally prohibit all people from doing such an act, they have interpreted to permit some people to do it, and they have adjudged to reach to some persons only, which expositions have always been founded on the intent of the Legislature, which they have collected sometimes by considering the cause and necessity of making the Act, sometimes by comparing one part of the Act with another, and sometimes by foreign circumstances. So that they have ever been guided by the intent of the legislature, which they have always taken according to the necessity of the matter and according to that which is consonant to reason and good discretion."

We can express it more simply by saying that the courts will interpret the provisions of a statute fairly and liberally in order to achieve the purpose of the Act.

III.2.C.4 PROVING YOUR CASE

The first step in learning to prepare an order or to prove a court case is to become familiar with the provisions relating to the order or the charge. All of the things which must be established will be found in the following provisions of The Environmental Protection Act, 1971.

The Environmental Protection Act, 1971, Section 1(c):

1. In this Act,
   (c) "contaminant" means any solid, liquid, gas, odour, heat, sound, vibration, radiation or combination of any of them resulting directly or indirectly from the activities of man which may,
      (i) impair the quality of the natural enfironment for any use that can be made of it,
      (ii) cause injury or damage to property or to plant or animal life,
      (iii) cause harm or material discomfort to any person,
      (iv) adversely affect the health or impair the safety of any person, or
      (v) render any property or plant or animal life unfit for use by man;

The Environmental Protection Act, 1971, Section 14:

(1) Notwithstanding any other provision of this Act or the regulations, no person shall deposit, add, emit or discharge a contaminant or cause or permit the deposit, addition, emission or discharge of a contaminant into the natural environment that,
   (a) causes or is likely to cause impairment of the quality of the natural environment for any use that can be made of it;

(b) causes or is likely to cause injury or damage to property or to plant or animal life;

(c) causes or is likely to cause harm or material discomfort to any person;

(d) adversely affects or is likely to adversely affect the health of any person;

(e) impairs or is likely to impair the safety of any person; or

(f) renders or is likely to render any property or plant or animal life unfit for use by man.

The Environmental Protection Act, 1971, Section 84:

(1) For the purpose of the administration of this Act and the regulations, a provincial officer may, from time to time and upon production of his designation, enter at any reasonable time any building, structure, machine, vehicle, land, water or air and make or require to be made such surveys, examinations, investigations, tests and inquiries, including examinations of books, records and documents, as he considers necessary, and may make, take and remove or may require to be made, taken or removed samples, copies or extracts.

(2) Where a provincial judge is satisfied, upon an ex parte application by a provincial officer, that there is reasonable ground for believing that it is necessary to enter any building, structure. machine, vehicle, land, water or air for the administration of this Act or the regulations, the provincial judge may issue an order authorizing a provincial officer to enter therein or thereon and to make or require to be made such surveys, examinations, investigations, tests and inquiries and to take the other actions mentioned in subsection 1 but every such entry,

survey, examination, investigation, test, inquiry and other such action shall be made or taken between sunrise and sunset unless the provincial judge authorizes the provincial officer, by the order, to so act at another time.

(3) Every person responsible for a source of contaminant shall furnish such information as a provincial officer requires for the purposes of this Act or the regulations.

The Environmental Protection Act, 1971, Section 83:

83(1) A provincial officer may survey from time to time anything that he has reason to believe is or may be a source of contaminant, and after completing such survey shall report his findings and his recommendations.

(2) The provincial officer shall file his report of his findings and recommendations with the Department and shall serve upon the person responsible for the source of contaminant a copy thereof. 1971, c.86, 3.83.

The Environmental Protection Act, 1971, Section 70:

70. The Director may, where he is authorized by this Act to issue an order known as a "control order", order the person to whom it is directed to do any one or more of the following, namely,

(a) to limit or control the rate of addition, emission or discharge of the contaminant into the natural environment in accordance with the directions set out in the order;

(b) to stop the addition, emission or discharge of the contaminant into the natural environment,

(i) Permanently

(ii) for a specified period

(iii) in the circumstances set out in the order;

(c) to comply with any directions set out in the order relating to the manner in which the contaminant may be added, emitted or discharged into the natural environment;

(d) to comply with any directions set out in the order relating to the procedures to be followed in the control or elimination of the addition, emission or discharge of the contaminant into the natural environment; and

(e) to install, replace or alter any equipment or thing designed to control or eliminate the addition, emission or discharge of the contaminant into the natural environment. 1971, c. 86, s. 70.

The Environmental Protection Act, 1971, Section 73:

73(1) Where the Director proposes to issue a control order he shall serve notice of his intention, together with written reasons therefor and a copy of the report of the provincial officer or other person designated under this Act upon which the reasons are based, and shall not issue the control order until fifteen days after the service thereof.

(2) The person to whom the Director intends to issue the control order may make submissions to the Director at any time before the control order is issued. 1971, c.86, s.73.

The Environmental Protection Act, 1971, Section 79:

79(1) A person to whom an order of the Director is directed may, by written notice served upon the Director and the Board within fifteen days after service upon him of a copy of the order, require a hearing by the Board. 1971, c. 86, s.79(1).

(2) No imposition or alteration of terms and conditions, suspension or revocation, refusal to renew, suspension or revocation under section 52c, shall be enforced until final disposition of an appeal, if any, or until the time for taking an appeal against the order has passed. 1971, c.86, s.79(2), c. 106, s.29.

Evidence

In order to prove a violation of section 14 or to prepare a report under section 83 of The Environmental Protection Act we must establish the following:

(a) Correct name of defendant.

If the defendant is a human being, then he may be charged in the name by which he is commonly known. But if he does use a nickname it is better to give his real name as well, for instance, "Charles Smith also known as Chuck Smith". If he carries on business under a trade name, then both names should be given, for instance, "Charles Smith, carrying on business as Chuck's Auto Body".

If the defendant is a partnership, then the names of all partners as well as the names under which they carry on business should be given, for instance, "Charles Smith and Peter Brown carrying on business as Metro Printers".

If the defendant is a corporation, then normally the name will include the word "Limited".

You may verify trade names by ordering a certificate from the register at the Ministry of Consumer and Commercial Relations, 965-7581, to be mailed from or picked up at 555 Yonge Street, Toronto.

You may verify corporate names by ordering a certified copy of the annual return of the same Ministry at 965-2556 to be mailed from or picked up at 555 Yonge Street, Toronto.

(b) Place of commission of offence or emission of contaminant.
You may verify this by obtaining a certified copy of the extract from the assessment roll from the clerk of the municipality.

(c) Date of commission of offence or survey.

(d) Nature of contaminant emitted.
Two separate components are included here. The nature of the contaminant should first be described in layman's terms, i.e. noise from an air conditioner. It shoukd then be described in terms of the requirements of section 1 (c) of The Environmental Protection Act, 1971 which defines "contaminant". This is essential because the power to regulate is limited to regulation in relation to contaminants, and a noise emission is by definition a contaminant.
Therefore, your testimony must establish all of the elements of the definition of a contaminant:
   (i) solid, liquid, gas, energy or combination thereof,
   (ii) results from activity of man,
   (iii) potentially harmful effects.

(e) Emission was audible, i.e. could be heard.
You must establish that it can be detected by the naked ear.

(f) Where a limit is specified, i.e. could be measured, you must establish the measured level, the procedure and standard applicable and the instrumentation used in the determination.

(g) Emission causes or permitted by the defendant.
This may be proven by showing that the defendant operated the plant from which the emission originated, or in the case of a machine, that the defendant was responsible for operating it, or having become aware of its existence, failed to act to abate it. This evidence is gathered by talking to the defendant or his employees about the circumstances surrounding the emission and can be used as an admission.
Before having any telephone conversation with a plant operator, meet the man so that you can identify his voice on the phone.
Regarding circumstances surrounding the taking of noise readings, NPC Publication 103 describes, in detail, the consideration which should go into each set of readings you take.

III.2.C.6. <u>EVIDENCE RELEVANT TO PENALTY</u>

In assessing penalty, the court will be influenced by the following factors:

(a) Circumstances surrounding the incident.
If the emission is from an industrial process you should outline for the court the following information:
(i) what the plant makes
(ii) simple description of the part of the process giving rise to the emission - illustrate with a sketch
(iii) reason for the emission - lack of control equipment, breakdown, etc.
(iv) length of time during which emission persisted
(v) action taken to correct situation.

(b) Harmful effects:
Look for the type of effects contemplated in section 14 (1) of the Act. (Also Regulation 15 Sec. 6). It will be useful in illustrating some of these points to obtain a map of the area or to prepare a sketch yourself. If the case is a big one, aerial and ground shots may be arranged through the Ministry of the Environment.

(c) Record of the defendant:
It is important to show whether the incident was an isolated occurrence or whether it was part of a pattern, because this type of evidence will assist the court in assessing the attitude of the defendant. You should also know something about the municipal record - whether the department concerned has been diligent in its efforts to secure abatement, as this is likely to arise in cross-examination.

III.2.C.7. WITNESSMANSHIP

Court Procedure

At the opening of preceedings the charge is read to the defendant by the Court Clerk and he is asked how he pleads. He may plead guilty or not guilty.

If the plea is "not guilty", then the trial will proceed.

The prosecution must then call all of its witnesses to establish its case. If, after all of these witnesses have been heard, the court is not satisfied with the evidence, it may dismiss the charge. If the court is satisfied that the case has been established then it will hear the evidence for the defence. If the defence raises new issues then, after all of its witnesses have been heard, the prosecution may call additional witnesses in reply.

After all of the evidence has been heard the lawyers present argument and the court determines whether on the basis of all of the evidence the defendant is guilty or not guilty.

You will be examined in 3 stages. First, you will be examined in chief by your own lawyer to elicit all of the facts upon which you rely to prove your case. Then you will be cross-examined by the defence lawyer. During cross-examination he will test your evidence by seeking to determine whether you had the opportunity to observe what you say you observed, and whether your opinions are well-founded. He may raise new issues which were not covered during examination in chief. When cross-examination is complete, you may be re-examined by your own lawyer with respect to any new matter raised on cross-examination.

Behaviour in Witness Box and in Court

Your physical appearance is very important in creating a good impression. Therefore, you must be neat and clean. A shirt, tie and sports jacket are minimum requirements.

Address the judge as "Your Honour", the defence lawyer as "Sir" or "Madam".

While in the courtroom waiting to be called sit quietly in your place and avoid talking to anyone or commenting on the proceedings.

Giving of Your Evidence

The general rule of evidence is that a witness may state only facts directly observed by him, i.e. what he saw, smelled, heard. He may not state his opinion based on those facts. It is up to the court to draw the proper inferences.

In certain cases however, special skill or knowledge are necessary to draw the proper inferences from facts. In these cases an expert is permitted to state his opinion.

In most prosecutions you will testify in both capacities. Your testimony with respect to the date, time, place, weather, plant process, etc., is testimony as to facts directly observed by you. But your testimony with respect to the effect of the emission of noise is an opinion based upon special skill acquired by training and maintained by practice.

In addition to these basic types of evidence, you will identify documentary evidence in the form of maps, sketches or photographs prepared by you or under your supervision and offered to the court to assist it by illustrating your testimony. You will also give evidence based on admissions by the defendant or its employees with respect to the incident.

It is quite permissible to review your notes shortly before trial to refresh your memory and then to give your evidence without reference to the notes. It is also permissible to take your notes into the witness box and refer to them from time to time. Before referring to notes in the witness box however you must satisfy the court that they were made by you at the time of the violation, or soon enough thereafter that the facts were still fresh in your memory, and that the information recorded was true.

If you do have to refer to your notes then it is likely that defence counsel will examine them. Therefore, when making them do not include anything except the facts of the case. If there are alterations, then you must be prepared to explain when and why they were made. If alterations are made subsequently, they should be dated.

If you conduct an investigation with someone else, then each of you should make your own notes. It is permissible for another person to refresh his memory from your notes however if he read them over at the time they were made, or while the facts were still fresh in his memory and was satisfied with their accuracy.

Try to give your evidence slowly, so that the judge and court reporter can record it. Take time to think about the answer to a question before you give it.

Listen carefully to the questions and be sure that you understand them before answering. If you have difficulty with a question, ask to have it repeated, or if necessary rephrased.

Some questions can be answered "yes" or "no" but to answer other questions without full explanation or qualification can be misleading. So do not allow yourself to be rushed through a question with an incomplete answer. Sometimes on cross-examination a lawyer will demand a "yes" or "no" answer. If this would be incomplete or misleading then advise the court of this and you will be directed to answer fully.

Defence counsel employ various techniques on cross-examination. Some of these techniques are calculated to confuse and upset you. If your evidence is true, and if you take time to listen carefully to the questions, and insist on answering them fully and carefully, then you have nothing to fear. If however, you allow yourself to be drawn into a feud with the defence lawyer, you may well emerge a loser.

Some of the destructive techniques employed are as follows:

(a) Insult the witness - suggest that he is biased, that his investigation is incomplete, that he does not know what he is talking about.

(b) Shout at the witness and display anger and disbelief at his answers.

(c) Rush the witness through a series of questions leading to a conclusion which follows logically from the answers but is wrong because some fact or qualification has been omitted.

Perhaps the best way to deal with these techniques is to give examples.

On cross-examination, the defence lawyer suggests that your testimony is biased, incompetent and that you are a fool. He then asks you if you feel that you are in an adversary position. If you say "no", it may appear that you are admitting that you were biased or incompetent. Also no judge will believe that a person who has been humiliated does not feel that he is in an adversary position. If you say "yes", it may appear that you are prepared to slant your testimony to defeat the defence lawyer. The best way to handle this is just to respond honestly as a human being. Say that when you conducted your investigation and prepared your report you did not feel that you were in an adversary position but that the conduct of the defence counsel has made you feel that you are in an adversary position. This establishes you as an honest, normal guy, and the defence lawyer as a scoundrel.

If you are asked a series of questions, leading logically to a certain conclusion that is wrong, then admit the conclusion does follow logically but explain what was not taken account of and which changes the conclusion. If you cannot put your finger on the flaw, then say that you feel it is wrong and cannot at the moment see the reason but would like to think about it and answer later.

Sometime during your testimony you may make an error and give a wrong answer. If this happens it can be corrected on re-examination. Sometimes, however, an earlier wrong answer will be used on cross-examination by the defence lawyer. If this happens, you should acknowledge the earlier error and correct it at once.

Use of Notes in Court

Because a trial may take place many months after the violation occurred, it is important to take accurate, detailed notes at the time of the violation or soon enough afterwards that the facts were still fresh in your memory. The notes may be in your own handwriting or typed. If they are typed, then they should be signed. All notes should be dated.

Sometimes your testimony may be interrupted for a brief recess for a luncheon break, or even at the end of the day. If you are being cross-examined at this point, then you must remember not to discuss your testimony with anyone with one exception - you may discuss it with your lawyer.

You will be glad to know that cross-examination is usually quite harmless. Most lawyers ask questions which give you an opportunity to bring in all sorts of information that we could not introduce in chief, which is damaging to the defendant. Usually the type of evidence that you can give relates to the conduct of the defendant over the years, based on information and reports in the file, and not necessarily on personal knowledge.

In summary, we must recognize that when testifying you will be in a situation which will subject you to stress - even the friendly examination of your own lawyer will do this. The best way to deal with it is to conduct a thorough, fair investigation, familiarize yourself fully with the case before trial, and then testify fully, frankly and openly using notes where necessary, without suppressing your own personality in an attempt to adhere to some idea that a credible witness must behave like some kind of robot, without feelings, or fears, or weaknesses.

III.2.C.4. ISSUANCE OF A CONTROL ORDER

In order to illustrate the time and patience required in carrying out an investigation arising from a noise complaint through to the final deicision taken to issue a Control Order under the Environmental Protection Act; the following case history is presented for study;

All the documentation concerning KELSON SPRING PRODUCTS LIMITED produced in the manual is in the public domain. Kelson is in the process of appealing the Control Order to the Environmental Appeal Board at this time.

For the purposes of this manual the following facsimile documents are reproduced:

1) Synopsis of case history from receipt of the first complaint concerning Kelson Spring Products Limited, Brandon Street, Toronto, plant.

2) Report of Provincial Officer, David Fumerton, dated August 18, 1975, pursuant to EPA Section 6 and 83, filed with the Department and a copy served on the person responsible for the source of contaminant noise.

3) Notice of Intention to issue a Control Order served on August 21, 1975, pursuant to EPA Section 6 and 73.

4) Control Order served on Kelson Spring Products Limited on September 22, 1975, requiring initial abatement action by October 15, 1975, and permanent abatement by January 1, 1976.

MINISTRY OF THE ENVIRONMENT

CONTACTS REGARDING (AND MEASUREMENTS AT) KELSON SPRING PRODUCTS LTD.

FILE SYNOPSIS - Our Ref. 0423 INDP

May 30, 1973	Call from a complainant, alleging plant and truck noise.
June 19, 1973	MOE advised noise producer on phone of alleged noise sources, who denied the possibility.
June 29, 1973	MOE called the complainant who confirmed complaints, and alleged he represents others.
September 10, 1973	Complainant sends letter to Premier detailing plant and truck noise. (Premier's office requests on October 25, 1973 that Noise Supervisor reply directly, and encloses copy of Premier's letter of November 8, 1973 saying MOE would contact the complainant).
November 16 and 19, 1973	MOE investigated and observed several in-plant noise sources and also truck noise. On this visit the noise was not judged excessive, but it was noted that sealing doors and windows could reduce plant noise, and truck noise could be reduced by stopping idling.
December 31, 1973	MOE writes to complainant that we have been unable to meet him personally to discuss measurements at his premises.
January 15, 1974	Complainant was visited. He repeated noise complainants and alleged he acted for other complainants too.
January 15, 1974	Measurements taken, excess not observed. Same conclusions as for November 16 and 19.
February 19, 1974	MOE Noise Supervisor writes to the complainant that we will suggest to company ways to abate noise, and re-evaluate the situation after noise regulations promulgated.
February 19, 1974	MOE Noise Supervisor writes to company that until regulations are promulgated, noise can be judged subjectively only, and suggests that closing doors and windows and being careful with truck loading may help. (No reply ever received.)
March 8 and 11, 1974	Complainant phones and alleges no improvement since our letter.
March 18, 1974	Complainant writes that noise continues.

NOTE: For the sake of brevity the log from March 18, 1974 to March 20, 1975 is omitted here, and is available in the Ministry's file to those interested.

Correspondence Log Continued from March 18, 1974

March 20, 1975	Complainant complained. MOE visited and found doors open and fork lift truck usage produced high excess noise - but short-lived as fork lift truck disappeared.
March 25, 1975	Complainant phoned and MOE visited and measured prolonged excessive noise from fork lift truck, as well as excessive noise from plant through open door. Deposition forms were left with complainant, who was told that if adequate evidence of material discomfort found we would recommend prosecution.
April 3, 1975	14 sets of deposition forms were received.
April 9, 1975	Provincial Officers Report filed by D. Fumerton and D. May.
April 30, 1975	Letter received from Commissioner of Development, City of Toronto, requesting information on legal action against Kelson.
May 20, 1975	Premier acknowledges letter form the complainant.
May 26, 1975	An MPP writes to Minister acknowledging visit to Kelson Springs with Supervisor.
June 18, 1975	Letter from Kelson disclosing that old Tollmotor (lift truck repaired) and that purchase of new (silenced) electric lift truck has been initiated.
June 19, 1975	Provincial Officers Report filed by L. Butko, D. Fumerton and R. Purchase.
July 3, 1975	Letter from Kelson confirms delivery of new electric lift truck.
July 17, 1975	Supervisor recommends that Director proceed with legal action.
August 21, 1975	Notice of Intention to serve a Control Order on Kelson issued by Director.
September 22, 1975	Control Order served on Kelson with interim date of and completion date of January 15, 1976.
	Control Order served on Kelson Spring Products Limited requiring initial abatement action by October 15, 1975, and permanent abatement by January 1, 1976.
October 20, 1975	Control Order appealed to Environmental Hearing Board by Kelson.
January 20, 1976	Notice of Hearing by Environmental Appeal Board on February 11, 1976. Advertised publically.

REPORT OF PROVINCIAL OFFICER :

REPORT AND RECOMMENDATIONS
of a Provincial Officer Pursuant
to The Environmental Protection Act, 1971, Section 33

Source of Contaminant:

Kelson Spring Products Ltd. manufacture bed springs in their plant located at 103 Brandon Avenue, Toronto.

Date of Survey:

On March 25th and June 10, 1975 a survey of the noise emissions from this plant was conducted by Daryl May, Leo Butko, Dave Fumerton and Ron Purchase, all Provincial Officers with the Ministry of the Environment.

Reason for Survey:

Prior to the initiation of this survey there was reason to believe that this plant was a source of contaminant, namely sound, because

(a) residents living in close proximity to the plant had made a series of complaints with respect to noise emissions from the plant over a period of about 3 years;

(b) Provincial Officers investigating these complaints from time to time were able to verify these complaints by personal observation;

(c) Provincial Officers attempting to work with the company toward voluntary abatement had access to the plant and its management and the reports of its consultants with respect to the emissions and the measures necessary for their abatement.

As no action was taken by the company to implement the measures recommended by its consultants, this survey was was prepared as the basis for the issuance of a control order.

Plant Location:

This plant is located on the north side of Brandon Avenue and is bounded to the west by Primrose Avenue and north by Chandos Avenue. Private homes are located

on the south side of Brandon Avenue, the east side of Primrose and the north side of Chandos. A sketch illustrating the relative locations of the plant and the houses as well as the observation points used during the survey is attached and labelled as Exhibit No. 1.

Source of Sound Emissions:

There are two sources of sound emissions from this plant:

(a) the manufacturing operations;

(b) the unloading operations on Chandos Avenue.

The sound from the manufacturing operations is emitted into the natural environment from open doors and wondows along the laneway separating the plant from the houses on Primrose Avenue, and from the doors and windows facing Chandos and Brandon Avenue.

Wire stock and other materials used in the manufacture of bed springs are delivered to the plant by truck. These trucks are unloaded on Chandos Avenue with the use of fork lift trucks. Sound is emitted into the natural environment from these unloading operations.

Significance of Sound Emissions:

Sound causes vibration of air particles. This vibration is sensed by the human ear as sound. This sound can be measured using a sound level meter which measures the fluctuations in air pressure caused by the vibration of air particles and records the levels on a scale known as a dBA scale. The dBA scale approximates the response of the human ear to the audible frequency spectrum.

The Ministry of the Environment has established criteria prescribing the maximum sound pressure levels for various urban areas including residential areas adjacent to busy streets, related to commercial activity or to industry. These criteria reflect average existing background noise levels found to exist across Ontario. The maximum dBA level during daytime hours is 65 dBA, the maximum level during night time hours and Sundays and holidays is 55 dBA.

On March 25, 1975 between the hours of 8:45 a.m. and 9:30 a.m., we observed the noise from a fork lift truck operating on the sidewalk and street of the Chandos Avenue entrance to the above premises. Through the use of a sound level meter, the sound level from this source was measured on the property of 118 Chandos Avenue, a residence, and found to read 76 dBA (decibels "A" scale), and to exceed 70 dBA on thirty occasions. During a lull in the fork lift truck operation, we measured the plant noise, the background level of 56 dBA was measured.

On June 10, 1975 sound level measures were taken between the hours of 7:00 a.m. and 6:00 p.m. at two locations:

(a) at 118 Chandos Avenue;

(b) at 57 Primrose Avenue.

Unloading operations took place on Chandos Avenue for 27 minutes between 11:20 and 11:47 a.m. and the resulting sound levels measured at 118 Chandos Avenue were 74 - 76 dBA.

Measurements taken between 11:20 and 11:28 a.m. at 57 Primrose Avenue showed sound levels above 70 dBA. Of 79 measurements taken at this location between 7:00 a.m. and 6:00 p.m., 63 measurements showed sound levels above 65 dBA.

Effects of Sound Emissions

Over a period of about three years, sound from this plant has had these effects:

1. Residents have been unable to converse with one another in a normal fashion.

2. Shift workers have been awakened from sleep during daytime hours by noise.

3. Residents have had to close doors and windows in their houses to reduce noise.

4. Residents have been unable to use verandahs and gardens for recreation and relaxation due to noise.

5. Residents have suffered severe annoyance and stress from noise.

Feasibility of Control:

Emissions of sound from this plant into the natural environment may be reduced to levels falling within the criteria prescribed by the Ministry by

(a) sound emissions from the unloading operations on Chandos Avenue could be eliminated by unloading these materials in the enclosed loading docks on Brandon Avenue;

(b) sound emissions from the manufacturing operations in the plant could be controlled by sealing existing doors and windows with effective sound insulating materials. Windows would be kept closed at all times and doors would also be kept closed except as required for normal entry and exit from the plant. It is recognized that keeping doors and windows shut may require ventilation of the building and that any ventilation system must be designed so that excessive noise emissions do not occur.

Findings:

The emission of sound from the operation of this plant into the natural environment

1. has caused and is likely to continue to cause impairment of the quality of the air for use as a medium for communication between human beings, contrary to section 14(1) (a) of The Environmental Protection Act, 1971.

2. has caused and is likely to continue to cause loss of enjoyment of normal use of property by interfering with sleep, ventilation of houses and use of yards and verandahs for recreation and relaxation, contrary to section 6(b) of Regulation 15.

3. has caused and is likely to continue to cause material discomfort to persons, contrary to section 14(1) (c) of The Environmental Protection Act, 1971.

Recommendations:

It is recommended that sound emissions from this plant be controlled so that they meet the criteria prescribed by the Ministry of the Environment.

Specifically it is recommended that the following steps be implemented:

1. Sound emissions from manufacturing operations be controlled by sealing existing doors and windows with effective sound insulating materials.

2. Windows must be kept closed at all times.

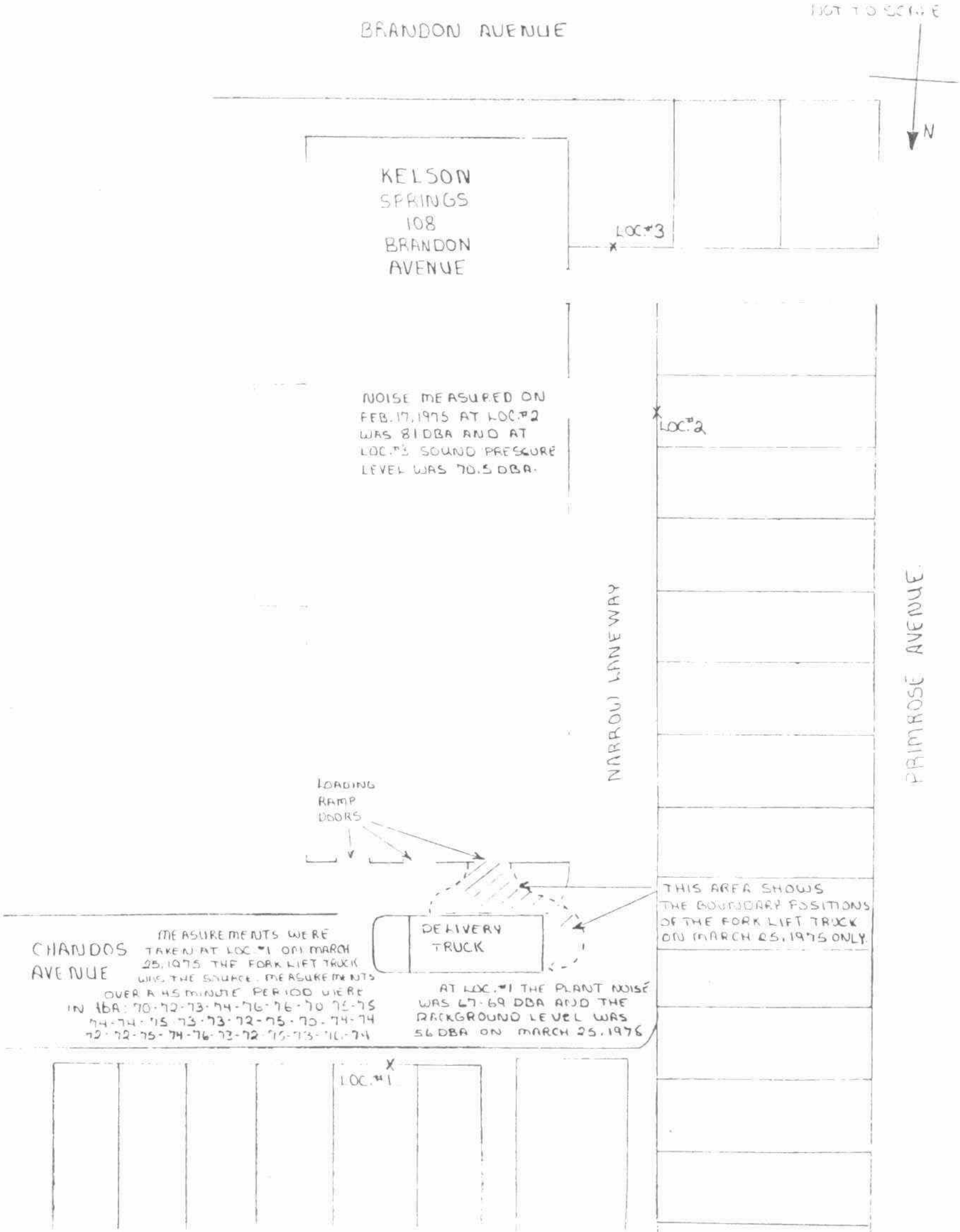
3. Doors must be kept closed except as required for normal entry and exit.

4. Any ventilation equipment must be silenced.

5. Unloading operations on Chandos Avenue must cease.

ISSUED at Toronto
this 18th day of
August, 1975.

David Fumerton,
Provincial Officer,
Noise Inspector,
Ministry of the Environment.



NOT TO SCALE
N
BRANDON AVENUE
KELSON SPRINGS 108 BRANDON AVENUE
LOC.#3
NOISE MEASURED ON FEB.17,1975 AT LOC.#2 WAS 81DBA AND AT LOC.#3 SOUND PRESSURE LEVEL WAS 70.5 DBA.
LOC.#2
NARROW LANEWAY
PRIMROSE AVENUE
LOADING RAMP DOORS
THIS AREA SHOWS THE BOUNDARY POSITIONS OF THE FORK LIFT TRUCK ON MARCH 25,1975 ONLY.
DELIVERY TRUCK
CHANDOS AVENUE
MEASUREMENTS WERE TAKEN AT LOC.#1 ON MARCH 25,1975 THE FORK LIFT TRUCK WAS THE SOURCE. MEASUREMENTS OVER A 45 MINUTE PERIOD WERE IN dBA: 70-72-73-74-76-76-70 75-75 74-74-75-73-73-72-75-70-74-74 72-72-75-74-76-73-72-75-73-76-74
AT LOC.#1 THE PLANT NOISE WAS 67-69 DBA AND THE BACKGROUND LEVEL WAS 56DBA ON MARCH 25,1976
LOC.#1

Ontario

MINISTRY OF THE ENVIRONMENT

NOTICE

TO: Kelson Spring Products Limited
108 Brandon Avenue
Toronto, M6H 2E1

Attention: Mr. Henry Kelson.

TAKE NOTICE that pursuant to the authority vested in me by Section 6 of The Environmental Protection Act, 1971, I intend to issue a Control Order directed to you in relation to the emission of the contaminant sound from you bed spring manufacturing plant located at 108 Brandon Avenue in the City of Toronto, into the natural environment.

This order will direct you to take the following steps to control and eliminate the emission of sound from plant operations into the natural environment.

1. By October 15, 1975 unloading operations on Chandos Avenue must cease.

2. By January 1, 1976 all doors and windows in the plant must be sealed with effective sound insulating materials so that the emission of sound from manufacturing operations within the plant will not exceed the criteria prescribed by the Ministry of the Environment.

3. By October 15, 1975 all windows must be kept closed at all times.

4. By October 15, 1975 all doors must be kept closed except as required for normal entry and exit.

5. Any ventilation equipment must be designed and installed so that the emissions of sound from the plan will not exceed the criteria prescribed by the Ministry of the Environment.

I intend to issue this Control Order because the report of David Fumerton, Provincial Officer, issued August 18th, 1975, filed with the Ministry contains these findings in which I concur:

The emission of sound from the operation of this plant into the natural environment:

1. has caused and is likely to continue to cause impairment of the quality of the air for use as a medium for communication between human beings contrary to section 14(1)(a) of The Environmental Protection Act, 1971.

2. has caused and is likely to continue to cause loss of enjoyment of normal use of property by interfering with sleep, ventilation of houses and use of yards and verandahs for recreation and relaxation, contrary to section 6(b) of Regulation 15.

3. has caused and is likely to continue to cause material discomfort to persons, contrary to section 14(1)(c) of The Environmental Protection Act, 1971.

UNDER Section 73 of The Environmental Protection Act, 1971, I may not issue this Control Order until fifteen days after service of this notice. You may make submissions to me at any time before it is issued. These submissions may be oral or written and must be addressed to:

ISSUED at Toronto
this 21st day of
August, 1975.

Director
Pollution Control Branch
Ministry of the Environment

Ontario

MINISTRY OF THE ENVIRONMENT

CONTROL ORDER

TO: Kelson Spring Products Limited
108 Brandon Avenue
Toronto, Ontario M6H 2E1

Attention: Mr. Henry Kelson

TAKE NOTICE THAT by this Control Order made pursuant to The Environmental Protection Act, 1971, you are hereby ordered:

The report of David Fumerton, Provincial Officer, filed with the Ministry on August 11, 1975 and accepted by me, found that the emission of sound from your bed spring manufacturing plant located at 108 Brandon Avenue, in the City of Toronto, was in contravention of Section 14(1)(a) and 14(1)(c) of The Environmental Protection Act, 1971 and in excess of the maximum permissible levels prescribed in Section 6(b) of Regulation 15.

Notice of my intention to issue a control order was served on you on August 21st, 1975.

Therefore, pursuant to the powers vested in me by Section 6 of The Environmental Protection Act, 1971, I hereby order you to do the following:

1. By October 15, 1975 unloading operations on Chandos Avenue must cease.

2. By January 1, 1976, all doors and windows in the plant must be sealed with effective sound insulating materials so that the emission of sound from manufacturing operations within the plant will not exceed the criteria prescribed by the Ministry of the Environment.

3. By October 15, 1975 all windows must be kept closed at all times.

4. By October 15, 1975 all doors must be kept closed except as required for normal entry and exit.

5. Any ventilation equipment must be designed and installed so that the emissions of sound from the plant will not exceed the criteria prescribed by the Ministry of the Environment.

MOE 03 002 7 74

Pending implementation of this control order you will take all steps necessary to minimize the emission of sound from your plant into the natural environment.

This order applies from the time that it becomes enforceable in accordance with the provisions of Section 79(2) of The Environmental Protection Act, 1971, until January 1, 1976.

Under Section 79 of The Environmental Protection Act, 1971, you may require a hearing by the Environmental Appeal Board if within fifteen days after service upon you of a copy of this order you serve written notice.

Notice requiring a hearing should be served upon:

T.M. Murphy
Secretary
Environmental Appeal Board
5th Floor
1 St. Clair Avenue West
Toronto, Ontario

and

K.E. Symons
Director
Pollution Control Branch
Ministry of the Environment
6th Floor
135 St. Clair Avenue West
Toronto, Ontario

ISSUED at Toronto this
22nd day of September,
1975.

K.E. Symons,
Director.

III.2.C.9. PROSECUTION USING THE MUNICIPAL NOISE CONTROL BY-LAW

Until more Municipal environmental noise case history has been recorded using the powers of the Environmental Protection Act, advice on the necessary procedures is preliminary advice. Here are some suggestions on procedure the Noise Control Officer may wish to adopt in investigating a noise complaint. Legal Counsel should always be consulted in case of doubt.

Where the noise is prohibited or limited under a section of the by-law without specific sound level limits, the alleged offender must be asked to cease and desist. Failure to comply within a reasonable time may be grounds for laying an information and, therefore, a detailed written record of all the pertinent factors involved in the matter must be kept by the Noise Control Officer in case the matter goes to Court.

Where the noise exceeds a sound level limit the noise producer must be given the results of any noise measurements, and informed that the noise is held to be excessive according to a certain section of the by-law which should be quoted. The information may, in the first instance, be given verbally and then followed up in writing stating the date and time of the alleged offence. The noise producer must be asked to stop or abate the noise. An offer should be made in the letter to answer questions or to discuss the feasibility of a solution.

Preparing for Court Action

The Municipality's legal counsel will find the following documents helpful in considering and taking legal action:

a) Copies of all the documents mailed to the noise producer, including the letter mentioned above.
b) An indication of the likely abatement methods to solve the problem. (That there is a feasible solution will avoid a successful defence based on argument to the contrary).
c) A list in chronological order, stating the dates of the various contacts with noise producer and complainants, giving a one-line synopsis of each contact. (This will enable the solicitor to refer to the file more easily).

d) Examples of typical documents that may be found in the file are listed below:

(i) Violation Notice - The Municipality may wish to use a similar form of Violation Notice for the purpose of warning a noise offender of an existing problem. (Figure III.2.C.1.)

(ii) Laying the charge. The form "INFORMATION OF..." is used to describe the alleged offence and must be signed by the informant and a Justice of the Peace (Figure III.2.C.2.)

(iii) The subpoena commonly issued and served as a result of laying the information may be a civil subpoena if the Municipal noise by-law is allegedly contravened (Figure III.2.C.3.) or a subpoena to a criminal action if the Environmental Protection Act and/or Regulation is allegedly contravened. (Figure III.2.C.4.) In either case, the subpoena must be served by an Officer of the Court from the judicial district concerned.

Ontario

Ministry of the Environment

Violation Notice

Observation Period ______________ a.m./p.m. Date ______________ 19____

Address ______________

Premises known as ______________

____

Name of Owner and/or Operator of Premises:

____

Address ______________

____

Violation of the Ontario Water Resources Act ☐

Violation of the Environmental Protection Act, 1971: ☐

Section ______________ Subsection ______________

Regulation no. ______________ Section ______________ Subsection ______________

Details ______________

____

____

____

This notice served upon ______________

at ______________ a.m./p.m. on ______________ 19____

Provincial Officer ______________

District Office ______________

Address ______________

13951

MOE 19-008 7 - 74

ORIGINAL

Figure III.2.C.1: Violation Notice Form

CANADA
PROVINCE OF ONTARIO
COUNTY OF

....

INFORMATION of ....

of ....

....(occupation). The informant says

that he has reasonable and probable grounds to believe and does believe

(1) that

on or about the .... day of .... 19......, at the ....

of .... in the said County,

Sworn before me at the ....of

....in the said County this

.....................day of .... 19.......,

....

A Justice of the Peace in and for the said ....

.... *(County* or *Province)*

....

Informant

Date

Crown Elects to Proceed ☐ Summarily ☐ By Indictment ☐ Summary Conviction Offence(s)

Accused Elects Trial by ☐ Judge ☐ Judge and Jury

☐ Discharged ☐ Committed – ☐ Ordered to Stand Trial – ☐ With Consent of Accused and Prosecutor,

Without Taking or Recording – ☐ Any Evidence (or) – ☐ Further Evidence. Bail $..........................

☐ Accused Elects Trial by a Magistrate (Provincial Judge) ☐ Absolute Jurisdiction ....

Pleads ☐ Guilty ☐ Not Guilty ☐ Withdrawn

Found ☐ Guilty ☐ Not Guilty ☐ In Absentia

Fined $ ....& $ ....costs Time to pay ....

or .... Age ....

Probation for ....
Sentenced to
Imprisonment for ....

....

Provincial Judge

(Single Accused - No More Than Two Charges) (D205) (6/70)

Figure III.2.C.2. Summons

(Form 11)
(Section 627)

SUBPOENA TO A WITNESS

CANADA
PROVINCE OF ONTARIO
JUDICIAL DISTRICT OF
YORK

TO Mr. J. Manuel - Noise Pollution Control Section

of 135 St. Clair Avenue West, Toronto, Ontario

WHEREAS Kelson Spring Products Limited (accused)
has been charged that he on or about the six ~~day of~~ months ending August 13, 19 75,
at the Municipality of Metropolitan Toronto in the Judicial District of York, unlawfully did cause unnecessary noise, disturbing the inhabitants, contary to by-law 44-75 of the City of Toronto

and it has been made to appear that you are likely to give material evidence for the prosecution ~~or the defence~~.

THIS IS THEREFORE to command you to attend before the presiding Provincial Judge or Justice on Mon day, the 27th day of October next, at 10:00 o'clock in the fore noon, in the Provincial Courtroom 83
at 2265 Keele Street, Toronto

to give evidence concerning the said charge and to bring records of noise readings and other information in the files of the Ministry of the Environment.

Dated at The Municipality of Metropolitan Toronto this 25 day of September 19 75

A Justice of the Peace in and for the Province of Ontario.

MI 530
C.B.F.

Figure III.2.C.3. A Typical Subpoena Issued to a Witness (E.P.A.)

2618/74

FORM 57-71
N&G LTD

CIVIL SUBPOENA
(General)

In the County Court of the Judicial District of York

Between:

SAMUEL COLE and
MINNIE COLE

PLAINTIFF(S)

AND

ANTONIO GUISTO and
ARMANDO GUISTO

DEFENDANT(S)

Elizabeth the Second, by the Grace of God of the United Kingdom, Canada and Her other Realms and Territories QUEEN, Head of the Commonwealth, Defender of the Faith.

To ANTHONY TAYLOR, Acoustic Analyst **Greeting.**

We Command You to attend before His Honour County Court Judge

at Toronto on Monday day the 24th day of November 19 75

at the hour of 10:00 o'clock in the fore noon, and so from day to day* until the above cause is tried, to give evidence on behalf of the Plaintiffs

and also to bring with you and produce at the time and place aforesaid any books, records, documents, letters, papers, copies of letters and other writings in your custody, possession or power containing any entry, memorandum or minute relating to the matters in question in this action.

In Witness Whereof this subpoena is signed for the County Court of The Judicial District of York by ~~XX~~ Elberton Thompson

Clerk of the said Court at Toronto, this 17th day of November 1975.

Here insert until the above cause is tried, to give evidence on behalf of
or for examination for discovery *or as may be.*

Clerk

Figure III.2.C.4. A Typical Civil Subpoena Issued to a Witness (By-law)

SUBJECT

ENVIRONMENTAL ACOUSTICS - III

TOPIC: III.2.D. (Acoustics)

OBJECTIVES:

Trainee will be able to:

1. Define significance of "dominant source" and "secondary sources" in a multi-source noise situation;
2. Explain how they can be isolated and measured;
3. Calculate the sound pressure level at a point due to an array of sources.

III.2.D.1. DEFINITION OF DOMINANT SOURCE AND SECONDARY SOURCES IN A MULTI-SOURCE NOISE SITUATION:

The dominant source at a point is the source which, if measured in the absence of all the other noise sources present, would have a higher sound pressure level than any other source measured individually in a similar way and at the same point.

Secondary sources are all sources, other than the dominant source, which contribute significantly to the total sound pressure level.

Note:

- The dominance of a source depends on where the measurements are taken, and may also change with time.
- While sound pressure level has been referred to above, reference can be made to the sound source which: dominates particular frequency bands; or has the highest weighted sound pressure level; or is simply dominant subjectively, i.e. the loudest or the most annoying.

III.2.D.2. HOW DOMINANT AND SECONDARY SOURCES CAN BE ISOLATED OR MEASURED:

There are a number of ways to achieve this. Topics I.1.D., I.3.A., I.4.A.&B. and I.4.C.&D. should also be of interest in this respect.

1. Switching sources off and on.-By switching off all sources except one, that source can be measured. A similar result can be achieved by measuring at times when some sources do not operate.
2. Attenuating various sources.-Temporarily attenuating each source in turn enables one to achieve the same result. Baffles, noise enclosures or operating a source at lower settings are ways this is sometimes carried out.
3. Close-up measurements.-When the sources are not very close together, one can take measurements close to each source in turn, but in the far field only, presuming that the sound measured at each point is due predominantly to the nearby source. Calculating the likely sound level due to each source at the point where they are to be compared is next carried out, taking account of the distance and nature of the intervening and nearby environment (to account as far as possible for baffling, reflections, absorption, etc.).
4. Other Information

- Prediction methods or measurements at other sites may give sound levels which can be successfully applied.

-Sometimes the sources are known to have distinctive frequency sprectra, each different from one another. It may be possible from the total sound spectrum to conclude which parts are due to each source and thereby judge their relative predominance.

5. Listen

-Not necessarily conclusive, but often very instructive.

Example 1:

Total sound level from sources A,B,C,D is 68 dBA. The sound levels of each source with all the others off is:

A : 65 dBA
B : 62 dBA
C : 62 dBA
D : 51 dBA

A is the dominant source. B, C and D are secondary sources.

Example 2:

A plant contains a great many noise sources. When source A is turned off the sound level decreases 4 dBA. Is it the dominant source?

Yes. A reduction of 3 dBA would have been a halving of A-weighted sound level. Thus turning off source A has decreased the energy by more than half, implying that it contributed more than half the energy.

III.2.D.3. CALCULATION OF SOUND PRESSURE LEVEL FROM AN ARRAY OF SOURCES:

The theoretical attenuation of sound with distance from a point source discussed in topic I.1.C. is widely used in practice, whenever a non-directional source is sufficiently small or far enough away from the receiver. For instance, if a compact noise source in the middle of an open field produces 60 dBA at 5m, it will usually be found that at 50m it has attenuated by 20 log (50/5) or 20 dB . This generates a level of 40 dBA at 50m.

Example 3:

The steady noise sources present in a plant are individually measured as shown below in the second column. The ambient level in the area is 42 dBA without the plant operating.

Source	Level at 10 m (r_1)	Distance to Receiver (r_2)	Distance Attenuation (20 log r_2/r_1)	Level at Receiver	Total
Loader	86 dBA	110 m.	21 dBA	65 dBA	
Fan	74 dBA	95 m.	20 dBA	54 dBA	66 dBA
Hopper	73 dBA	105 m.	20 dBA	53 dBA	
Ventilator	70 dBA	60 m.	16 dBA	54 dBA	

The attenuation due to the distance between the receiver and the 10 m. measurement position can be calculated as shown in the column 4. The values shown in column 5 are obtained by subtracting the attenuation (column 4) from the measured level (column 2). Clearly, the loader dominates and fan and hopper are marginal secondary sources at the receiver position.

For complicated cases involving many noise sources, calculations can be performed on computer. Noise directivity, barriers, ground attenuation and reflections, not to mention wind, temperature gradients etc., all can make this analysis a good deal more complicated in practice.

Example 4:

Determine the dominant noise source at a house as a result of noises from a nearby plant and the residential air conditioner of a neighbour. The background is 41 dBA when the plant is closed and the air conditioner is switched off.

Source	Level at Distance r_1	r_1	Distance to Receiver (r_2)	Distance Attenuation (20 log r_2/r_1)	Level at House	Total
Fan	91 dBA	7 m.	500 m.	37 dBA	54 dBA	
Conveyor	68 dBA	50 m.	500 m.	20 dBA	48 dBA	
Cyclone	81 dBA	2 m.	500 m.	48 dBA	33 dBA	58 dBA
Residential Air-Conditioner	50 dBA	10 m.	5 m.	-6 dBA	56 dBA	

The dominant source is the air conditioner at the house although the higher levels were measured near the fan. If the receiver location is moved nearer to the plant, the fan may well become the dominant source.

SUBJECT:

ENVIRONMENTAL ACOUSTICS - III

TOPIC: III.3.A.& B.(Workshop)

OBJECTIVES:

Trainee will be able to:

1. Describe main features of graphical level recorder and statistical distribution analyser;
2. Connect together tape recorder, sound level meter, graphical recorder and statistical analyser and operate these to perform statistical analysis of prerecorded noise;
3. Compute cumulative distribution curve over specified time period for a given tape;
4. Obtain statistical descriptors L_1, L_{10}, L_{50} and L_{90} from cumulative distribution curve;
5. Explain the physical significance of L_1, L_{10}, L_{50} and L_{90} in terms of the actual noise situation on the tape;
6. Demonstrate how statistical descriptors measured for a recorded noise are dependent on the choice of computation period.

III.3.A.&B.1. LEVEL RECORDER:

The Level Recorder is a recording voltmeter which can trace out the variation of the noise level on a roll of calibrated paper. The level recorder type B & K 2305 is commonly used in noise control work. This particular recorder operates on the servo-principle, where the signal to be measured is applied across a range potentiometer of accurately controlled potential distribution. From this potentiometer a voltage is picked off by the writing system of the recorder and compared with a controlled reference voltage. The difference signal is amplified to drive the writing system until the null point is reached.

The controls of B & K 2305 level recorder are identified in the Figure III.3.A.&B.1. and are described below in detail.

1. Supply Voltage and Fuse
2. Power Toggle Switch:
   This switch controls the on - off switching of the power from the power line. When the switch is in the "on" position, the pilot lamp above the recording paper will light.
3. Motor Toggle Switch:
   This switch controls the on - off switching of the motor for the paper drive system.
4. Input:
   This is a coaxial socket for the normal B & K plugs. Banana plugs also can be used. The input voltage should not exceed 100V.
5. Ground Socket:
6. Input Attenuator:
   This rotary switch attenuates the input signal in six accurate steps of 10 dB each. In position "0" no attenuation is introduced by the circuit.
7. Input Potentiometer:
   This dial enables the input signal to be varied continuously over a range of approximately 12 dB. When in position "10", the attenuation is approximately 12 dB.
8. 100 mV REF. Pushbutton:
   When pressed it causes the reference voltage (100 mV mains frequency) to be fed to the input of the recorder.

(9,10) Range Potentiometer and Locking Knob:

Two types of Range Potentiometers can be used - logarithmic and linear types. For the purpose of recording noise level variation within

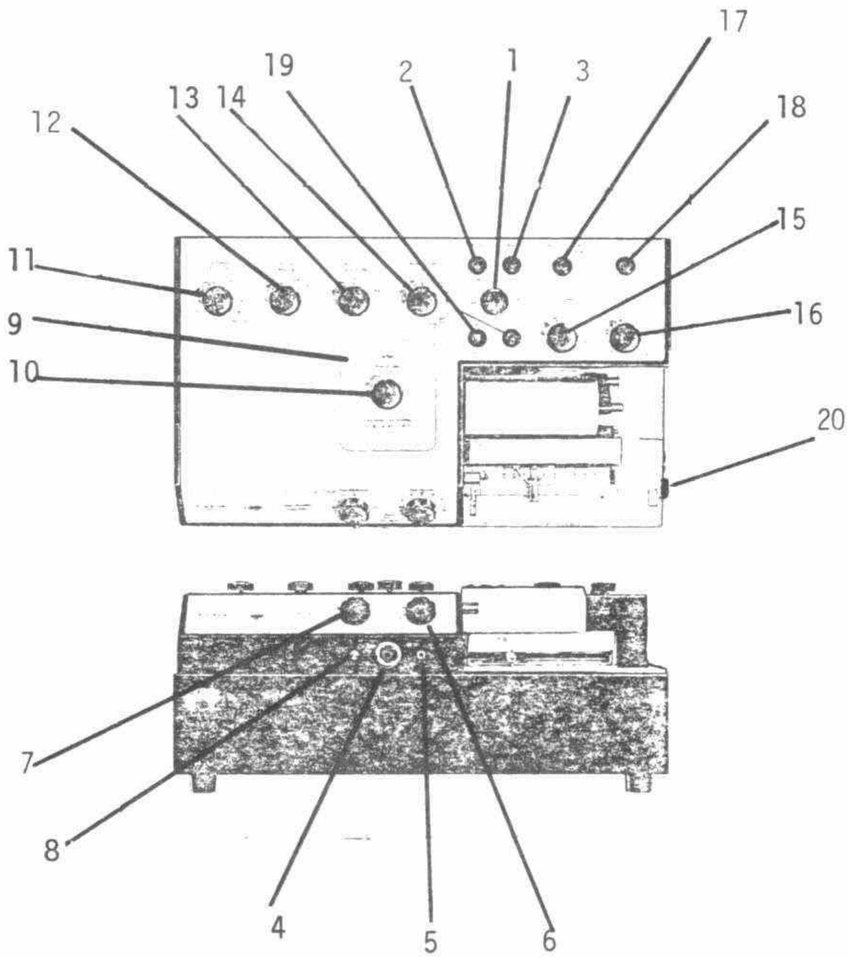


Figure III.3.A.& B.1.   Controls of B & K 2305 Level Recorder

50 dB range, the logarithmic range potentiometer of 50 dB is commonly used. However, logarithmic range potentiometers of 10,25 and 75 dB and linear range potentiometer of 10-35 mV, 10-110 mV are also available.

11. Potentiometer Range:
This rotary switch enables the resolving power of the recorder's writing system to be adjusted according to the range potentiometer used. With the logarithmic range potentiometer of 50 dB in use, the potentiometer range should be set to position 50. When employing this setting and a proper combination for lower limiting frequency and writing speed, stable function of the writing system will be ensured. The last position of this switch is marked "Stand by". When this position is used, the input to the output amplifier is grounded and the writing system will not respond to input signals.

12. Rectifier Response:
This switch enables the "Arithmetical(average)",the true "R.M.S." and the "Peak" level of an AC signal to be recorded. The last position of the switch marked "DC" is used when direct recordings of DC voltage are to be carried out.

13. Lower Limiting Frequency:
This rotary switch allows the averaging time to the rectifier and the negative feedback of the input amplifier to be changed according to the frequencies under measurement. To ensure stable functioning of the recorder and to avoid overshoot of the writing system, the position of lower limiting frequency and writing speed should be combined so that they correspond to the hatched area of Figure III.3.A.& B.2.

14. Writing Speed:
This rotary switch determines the damping (average time constant) of the writing system and is chosen in accordance with the type of recording required. The large figures of the writing speed calibration correspond to recording on paper of 50 mm width, and the small figures to recording on 100 mm paper width.

Note:
The settings of the writing speed which give the level recorder an averaging time approximately equal to the standarized meter characteristics "Fast" and "Slow" for sound level meters are 100 mm/sec. and 16 mm/sec. respectively, when the lower limiting frequency is kept at 20 Hz.

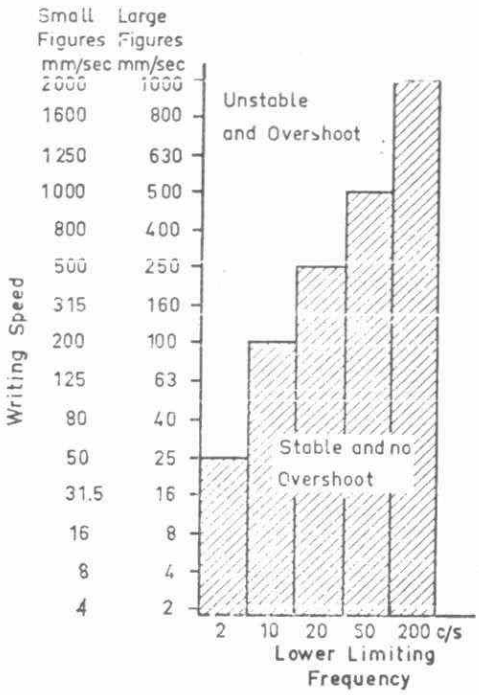


Figure III.3.A.& B.2: Relationship of Writing Speed Setting and Lower Limiting Frequency for Stable Operation of Writing System

15. Paper Speed:

This spring loaded rotary selector controls the speed of the recording paper. Twelve speeds from 0.0003 to 100 mm/sec. are available.

To change the paper speed lift the knob, turn it to the required position and release. It should be noted that the speeds corresponding to the inner and outer position of the synchronizing gear lever (marked 20 the Figure III.3.A.&B.1.) are indicated by large and small figures respectively. Further, when the synchronizing gear lever is in its inner position, only continuous recording can be carried out; in outer position both continuous and single chart recordings on pre-printed calibration paper are possible.

16. Drive Shaft Speed:
This spring loaded rotary switch controls the r.p.m. of the drive shaft in the gear box. Operation at different gear ratios between the paper speed and the shaft speed are obtainable through the use of knob positions marked "Paper Speed" and"Drive Shaft Speed".

17. Single Chart/Continuous Recording:
This makes start and stop of recording possible for both continuous and single chart mode of operation. To start continuous recording, the pushbutton is pressed down and locked by turning to the right.

18. Event Marking:
This pushbutton provides a means of marking the outer rim of the chart paper (between the left hand edge and the perforation holes) to signify noise events.

19. Stop-Start and Reverse-Forward Paper Drive Switches:
Stop-Start switch activates or stops paper drive. Reverse-forward switch makes reversal of the drive motor possible when repeated recordings on the same chart are desired.

Note:
Continuous recording can be also obtained by locking the "Single Chart/Continuous Recording"pushbutton in its down position, but in this case the paper drive can only be stopped by releasing the same button and with Paper Drive on "Stop". It is recommended to make continuous recordings with the gear lever pushed in.

III.3.A.& B.2. STATISTICAL DISTRIBUTION ANALYSER

This analyser arranges the recorded information of community noise into twelve class intervals on the basis of levels in dBA and presents a numerical display of the data. The analyser consists of three basic components:-a Generator, a Period Counter and Channel Counters.
The Generator produces short pulses, each of which can cause a counter or counters, to register one more digit. Every pulse is recorded on the Period Counter (total register), and further, if any of the contacts are closed, some of the twelve channels will also register. The maximum figure on each counter is 999,999.

The controls of B & K 4420 statistical distribution analyser are identified in the Figure III.3.A.&B.3. and are described below in detail.

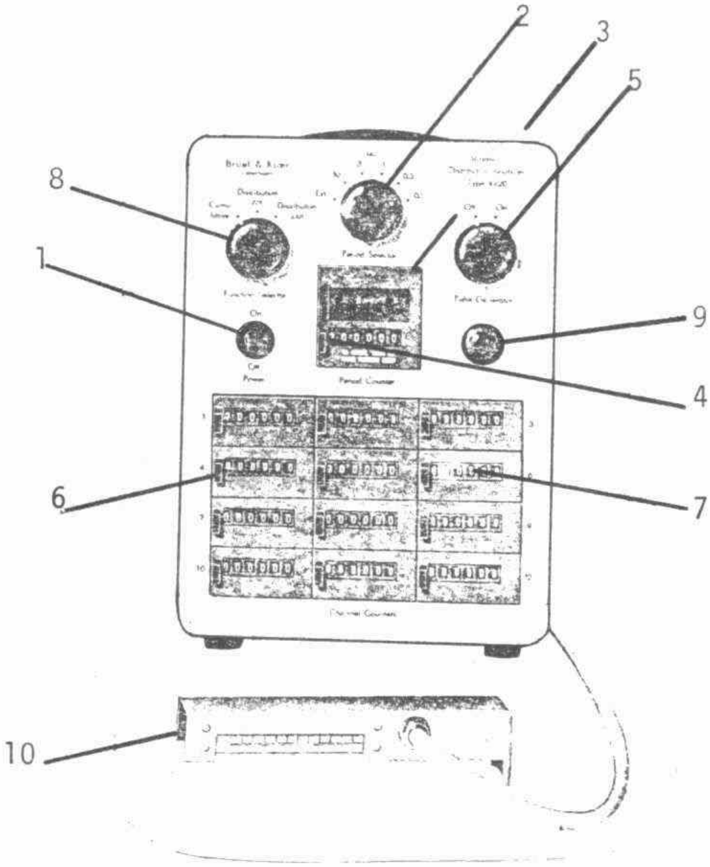


Figure III.3.A.& B.3. Controls of B & K 4420 Statistical Distribution Analyser

1. Power Toggle Switch:
   This switch controls the on-off switching of the power from the power line.

2. Period Selector:
   This dial selector allows choice of a suitable analysis period. External Operation is another mode and is used when a special pulse repetition frequency is required or when two 4420 analysers are to be synchronized together for signal analysis in more than 12 classes intervals.

3. Period Selector:
   The maximum desired count or target figure, is set behind the coloured window. When the period counter reaches this figure, counting stops. The drums are rotated by the finger, having raised the window while pressing the button to the left of the period counter.

4. Period Counter:
   This counts the total number of elapsed periods and can therefore be used as a total register.

5. Pulse Generator:
   This is to switch the pulse generator on or off,i.e. for starting the counting and for stopping it if the automatic stop has not already done so.

6. Zeroing Buttons:
   By manually pressing this button the corresponding counter returns to zero.

7. Channel Counters:
   The distribution of levels is shown on these counters.

8. Function Selector:
   Three different modes of counting are available on this dial selector.
   -"DISTRIBUTION-2305", is to obtain probability distribution histogram using level recorder. Here, by dividing the number of counts registered on each "Channel Counter" by the number of counts registered on the "Period Counter" a histogram as shown in Figure III.3.A.&B.4 can be plotted, which then is a measure of the statistical distribution of the sound level with time.

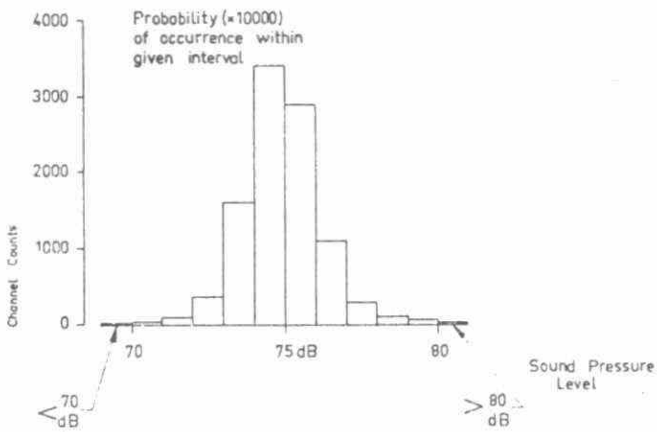


Figure III.3.A.& B.4: Example of a Probability Distribution Histogram

-"CUMULATIVE" mode is to obtain cumulative probability plot using level recorder. In this mode of operation, the instrument carries out electronically the process of summation over all the class intervals and cumulative curve as shown in Figure III.3.A.&.B.5. can be plotted directly from the numbers on"Channel Counters". It would be then possible to say from such a cumulative curve for what period the level exceeded a particular value.

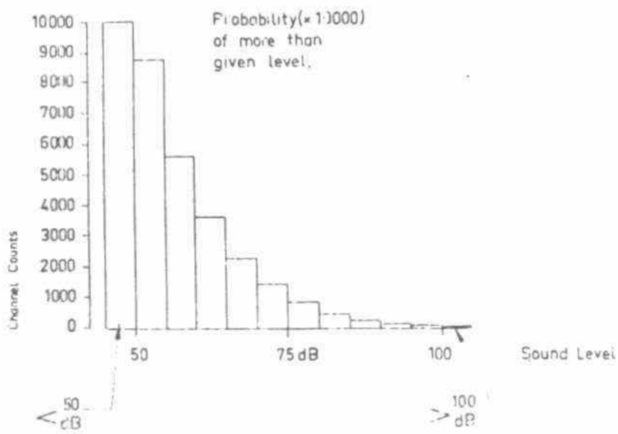


Figure III.3.A.& B.5: Example of a Cumulative Distribution Plot

In "DISTRIBUTION-2211"-mode of operation the statistical distribution analyser is used in conjunction with a multichannel instrument where the distribution of discrete event is being studied.

It will not be used in our analysis.

9. Pilot Lamp:
This indicates that the instrument is drawing power from either the mains or a 12 volt accumulator. When batteries are used, only two batteries are needed in addition to the accumulator, but this lamp gives no indication that they are connected.

10. Contact Device:
This device is connected to the contacts on the B & K type 2305 level recorder for statistical analysis.

Note:
Statistical distribution analysis of noise level varying with time can be performed in four ranges of "class intervals" 1, 2.5, 5, or 7.5 dB, as the dynamic range of the level recorder can be set to 10,25, 50 and 75 dB by means of interchangable potentiometers.

III.3.A.&B.3. CONNECTING LEVEL RECORDER AND STATISTICAL ANALYSER TO PERFORM STATISTICAL ANALYSIS:

Community noise exposure is usually irregular in character and a statistical approach must be used to express a behaviour otherwise difficult to describe.
A graphic record of the noise variation with time can be obtained on a chart of the level recorder for later statistical analysis, but this is a tedious and time consumming process. A much simpler and more reliable solution is to couple a statistical distribution analyser to the level recorder as shown in Figure III.3.A.&B.6.

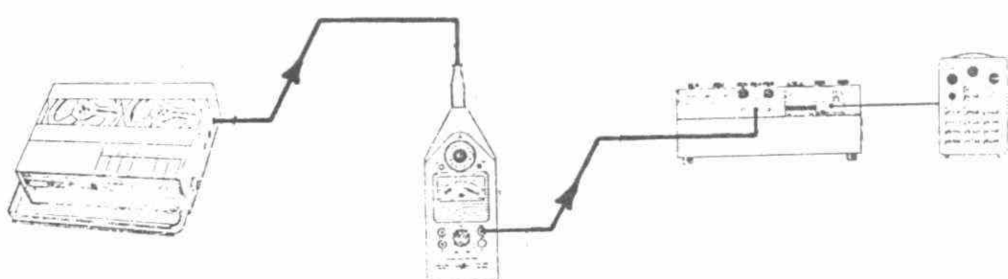


Figure III.3.A.& B.6. Measurement Set-up for Performing Statistical Analysis of Pre-recorded Noise

Here an electric signal from the "RADIO-PHONO" socket of the tape recorder (refer to the topic II.2.C.&D.) is fed to the sound level meter used as an amplifier and a weighting filter (A-weighting of a noise signal recorded at linear frequency characteristic is required). From the sound level meter output the signal is passed to the level recorder. Over the writing arm of the level recorder is clipped a 12 point contact row, each contact of which is connected to a time counter channel. Because of this arrangement a statistical distribution analyser connected to the level recorder can actually count the time for which the signal level is in a particular interval on the recorder scale.

Comparison of the time for which the signal has remained at particular levels with the total time elapsed gives a statistical level analysis of the noise event.

The following initial settings are used in the measurement set-up on Figure III.3.A.&B.6.

<u>UHER 4200 Stereo Tape Recorder</u>:

SPEED	"4.7 cm/sec."
CHANNEL SELECTOR	"Stereo"

<u>B & K 2203 Precision Sound Level Meter</u>:

OUTPUT ATTENUATOR	"Fully Clockwise"
FUNCTION SELECTOR	"A-weighting" & "Fast"

<u>B & K 2305 Level Recorder</u>:

POTENTIOMETER RANGE	"50 dB"
RECTIFIER RESPONSE	"RMS"
LOWER LIMITING FREQUENCY	"20 Hz"
WRITING SPEED	"100 mm/sec."
POWER	"on"
MOTOR	"on"
PAPER SPEED	"3 mm/sec."
INPUT ATTENUATOR	"o"

<u>B & K 4420 Statistical Distribution Analyser</u>:

POWER	"on"
FUNCTION SELECTOR	"cumulative 2305"
PERIOD SELECTOR	"0.1 sec."
PULSE GENERATOR	"off"

CALIBRATION:

a) A calibration tone of 94 dBA at 1000 Hz is recorded at the beginning of the tape for analysis. To locate this tone press the"START"key of the UHER and with the volume knob approximately mid-range find the beginning of the calibration signal. Press the "PAUSE" key on the UHER .

b) Pull the "FUNCTION SELECTOR" dial on the sound level meter "ON" and lift the "PAUSE" key on the UHER. Adjust the "INPUT ATTENUATOR" on the sound level meter to give a deflection in the upper 10 dB of the scale. Using a small screwdriver adjust the "ADJ" screw to give a meter scale reading of 4 dB.

c) Push and turn clockwise the "SINGLE CHART/CONTINUOUS RECORD" button on the level recorder and lower the pen. Adjust the "INPUT POTENTIOMETER" to give a pen deflection of 94 dB (i.e. on the sixth line down from the uppermost line on the paper). The level recorder chart (and hence the distribution analyser) is now calibrated so that the bottom line of the paper corresponds to 50 dBA and the uppermost line to 100 dBA.

d) Release the "SINGLE CHART/CONTINUOUS RECORD" pushbutton on the level recorder by turning anti-clockwise, raise the pen and press the"PAUSE" key on the UHER. The "INPUT POTENTIOMETER" knob on the level recorder should not be altered for the rest of the workshop unless instructed otherwise.

Analysis of a Taped Noise Sample:

Pre-recorded sample of noise is analysed for a period of 10 minutes following the listed procedure.

a) Set the "PERIOD COUNTER" on the distribution analyser to 6000. As the instrument is set to count every 0.1 second the count will be halted after 10 minutes.
Reset the "PERIOD COUNTER". Lift the red plastic cover and set the counter to 6000.
Reset all the other counters on the instrument.

b) Lift the "PAUSE" key on the UHER and run the tape to the beginning of the noise sample, press the "PAUSE" key to stop the tape.

c) Push and turn clockwise the "SINGLE CHART/CONTINUOUS RECORD" button on the Level Recorder and lower the pen. Lift the "PAUSE" key on the UHER to start the tape. Switch the "PULSE GENERATOR" knob on the Distribution Analyser to "ON".

JOB NAME: ____________________ Trainees Name: ____________________

LOCATION: ____________________

DATE : ____________________

STARTING TIME: ____________________ END: ____________________

TOTAL COUNTS

(1)	(2)	(3)
(4)	(5)	(6)
(7)	(8)	(9)
(10)	(11)	(12)

......dB Pot

Paper Calibration

......dBA

......dBA

Was the counter reset: Yes ☐ No ☐
to zero

Figure III.3.A.&B.7. Data Sheet For Entering Counter Settings of Statistical Distribution Analyser

d) As soon as the distribution analyser stops counting, press the "PAUSE" control on the UHER to stop the tape, release the "SINGLE CHART/CONTINUOUS RECORD" button on the level recorder to stop the paper and lift the pen.

e) Read the counts from the distribution analyser and enter in the sample data sheet of Figure III.3.A.&B.7.

III.3.A.&B.4. COMPUTATION OF CUMULATIVE DISTRIBUTION CURVE:

a) Using channel counts from the data sheet, cumulative Probability Plot can be drawn in Figure III.3.A.&B.8.

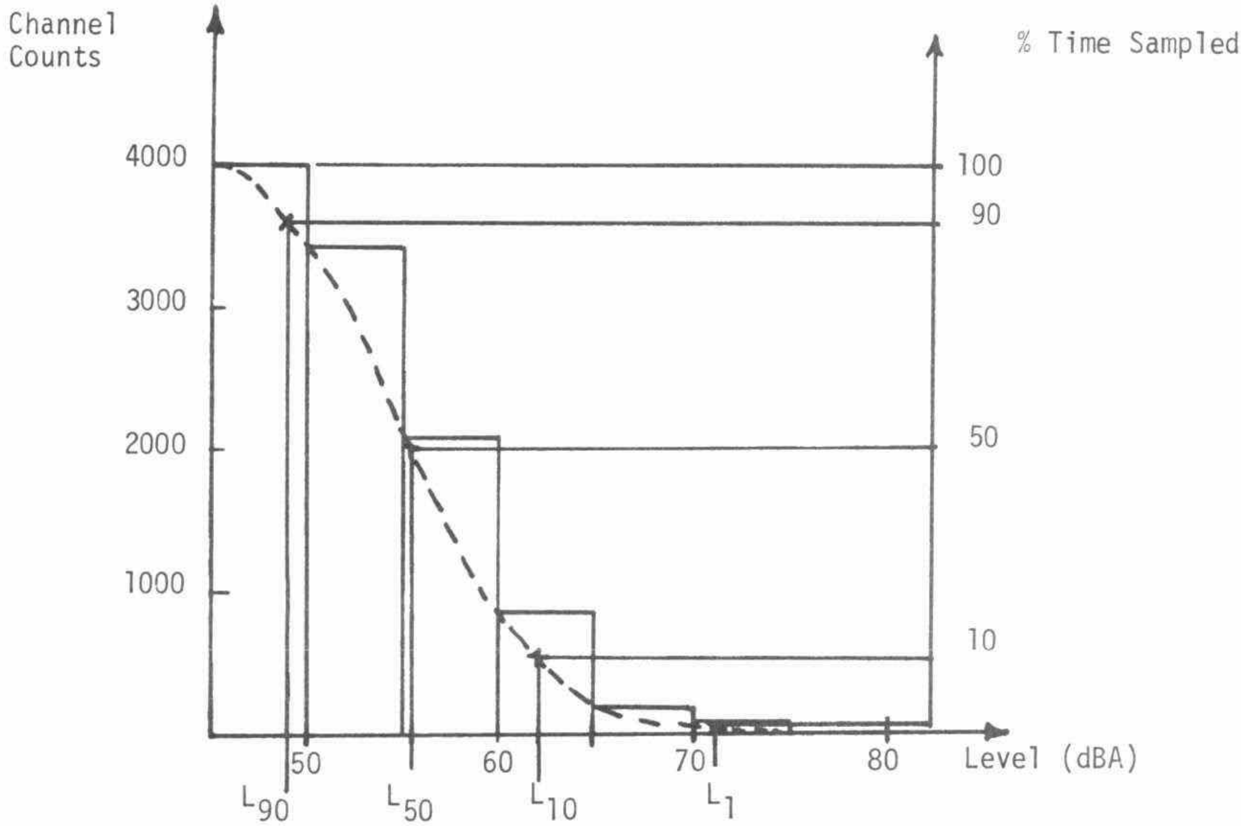


Figure III.3.A.& B.8: An Example of the Cumulative Probability Plot

A smaller curve (dotted) shown on Fig. III.3.A.&B.8. would result from using an analyser of infinitive resolution. The steps indicate the approximations that are caused by the use of a range potentiometer (5 dB class interval arising from the use of 50 dB logarithmic potentiometer).

III.3.A.&B.5 OBTAINING L_1, L_{10}, L_{50}, L_{90} FROM CUMULATIVE DISTRIBUTION CURVE:

From the Figure III.3.A.&B.8. the L_1, L_{10}, L_{50} and L_{90} values can be directly read off.

	L_1	=	72 dBA
	L_{10}	=	62 dBA
	L_{50}	=	56 dBA
and	L_{90}	=	49 dBA

III.3.A.&B.6 PHYSICAL SIGNIFICANCE OF L_1, L_{10}, L_{50} AND L_{90}:

Examine the noise level variation signature for the analysed 10 minute sample drawn on the level recorder. Notice how the statistical values obtained above seem to relate to the time history of the noise record on the chart paper as shown below.

L_1 - The level of all but the highest of the peaks - a good representation of virtually the highest sound levels found in the analysed sample.

L_{10}- This corresponds to the average level of intrusive sounds, but without representing very high peaks.

L_{50}- The middle of the range of sound levels, a kind of average.

L_{90}- The level corresponding to the generally quieter moments between noise intrusions but not absolutely quietest moment.

III.3.A.&B.7. DEPENDENCE OF STATISTICAL DESCRIPTORS ON COMPUTATION PERIOD:

The following pre-recorded tape is analysed in the demonstration.

-Continuous recording of community noise with distinct noise intrusions (15 minute duration).

-The following noise samples are analysed from the continuous tape:

- 1 sample, 10 second duration
- 3 samples, 10 second duration totalling 30 seconds
- 12 samples, 10 second duration totalling 2 minutes
- 30 samples, 10 second duration totalling 5 minutes

Next, all the samples and the continuous recording will be statistically analysed using measurements set-up shown in Figure III.3.A.& B.6.and the procedure outlined in III.3.A.& B.3. and III.3.A.& B.4.
The Cum ulative Probability Plot is then drawn and the values of L_1, L_{10}, L_{50} and L_{90} are obtained for all samples. A graph of sound level versus % time is plotted for the statistical descriptors; L_1, L_{10}, L_{50} and L_{90}. The statistical descriptors of continuous recording are compared with those for noise samples and presented graphically.

SUBJECT:

TOPIC: III.3.C.& D.(Workshop)

ENVIRONMENTAL ACOUSTICS - III

OBJECTIVES:

Trainee will be able to:

1. Use a sound level meter to measure particle velocity of a vibrating surface;
2. Outline the instrumentation set-up to measure peak particle velocity for instantaneous and intermittent type of vibration.

III.3.C. & D.1. THE USE OF A SOUND LEVEL METER FOR PARTICLE VELOCITY MEASUREMENTS:

Of the three vibration measurements displacement, velocity and acceleration, the one generally used in the by-law is velocity. This section of the course will deal with the use of a sound level meter with an accelerometer for the measurement of vibration velocity. The instructions given below apply to the specific application and should not be used in other situations.

The sound level meter to be used for the velocity measurement will be a B. & K. Type 2209 Precision Sound Level Meter. To prepare the 2209 for vibration measurement, the following steps are taken.

Step 1: Remove the meter scale by pulling the black bar to the right of the meter, turn the scale upside down and reinsert it. The Vibration Meter scale will now show.

Step 2: If a microphone is fitted, it should be removed. If not already fitted, a 1 inch adaptor should be screwed onto the input stage of the sound level meter. The B. & K. Type ZR 0020 Integrator should then be screwed onto the adaptor. The Integrator automatically converts from acceleration to velocity as required. Since in this case it will be used for velocity, the black knob on top of the Integrator should be set to "Vel "

Step 3: The attenuator scale on the 2209 will probably read in dB SPL if the instrument has been used for sound measurement. If so, this scale must be removed and a more suitable one inserted. To do this unscrew the central black portion of the attenuator (using a small coin if necessary). Lift off the clear plastic dial and lift off the scale in the attenuator. The scale should be replaced by scale No. 7A Make sure that the scale is properly located in the attenuator before the clear plastic dial and the central black portion are replaced.

NOTE: The microphone threads on B. & K. equipment are very fine and delicate and are easily damaged by cross threading. Extreme care is required in joining threaded parts.

Step 4: Finally, a B. & K. Type 4339 Accelerometer should be connected to the Integrator using a suitable cable. The sound level meter is now ready to be calibrated for vibration measurements. The complete set-up is shown in Figure III.3.C. & D.1.

Step 5 - Calibration: The easiest and most reliable way of calibrating an accelerometer is to have a device which can vibrate the accelerometer at a known acceleration. A typical vibration calibrator of this type is the General Radio Type 1557 Vibration Calibrator shown in the Figure III.3.C. & D.2. The accelerometer is mounted on one of the vibrating discs (using wax or double sided sticky tape) on either side of the calibrator. The instrument is turned to "Batt." and the battery checked. The instrument is turned to "On". The accelerometer used in this case weighs approximately 13 grams and the LEVEL knob should be used to give a needle deflection of 113 grams (the two discs weigh 100 grams). The accelerometer will now vibrate at 1 g (rms) with a frequency of 100 Hz. As we wish to do a velocity measurement, the velocity of the calibration vibration must be calculated.

$a = 1\ g$

$\therefore\ a = 9810\ mm/sec^2$, using equation III.2.A. & B.2.

now, $a = v\,2\pi f.$ (III.2.A. & B.4)

$$\therefore\ v = \frac{a}{2\pi f}$$

$$= \frac{9810}{2\pi.100} = 15.6\ mm/sec$$

It is convenient to calibrate and use the sound level meter to measure velocity in m/sec, and convert later to mm/sec.

$\therefore\ v = 0.0156\ m/sec$

One final adjustment must be made. As the above calculation was started with 1 g (rms) acceleration, then the value of v obtained was as follows:

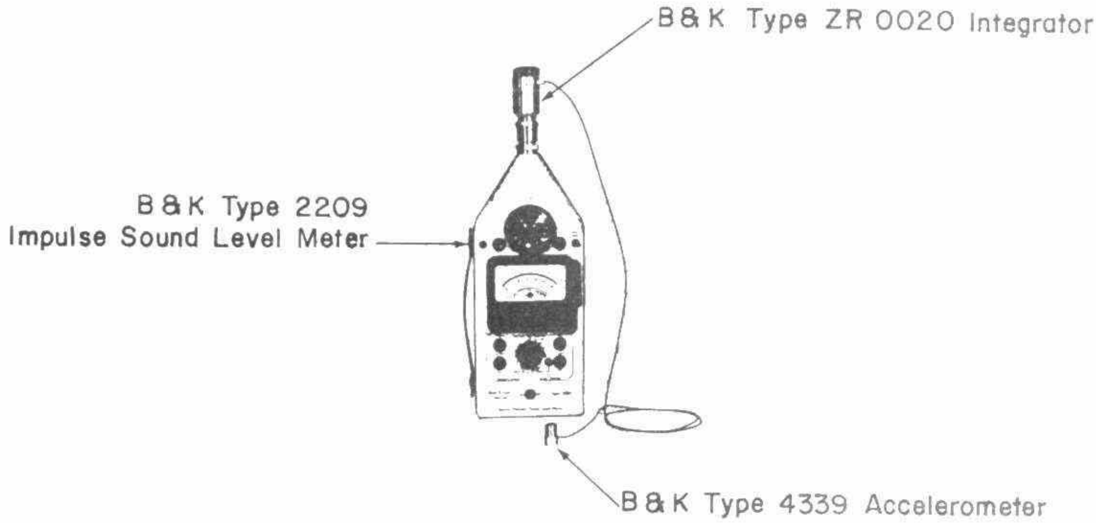


Figure III·3·C & D·1: Vibration Velocity Measuring Set-up

Vibrating Disc

Figure III·3·C & D·2: General Radio Type 1557-A Vibration Calibrator

$$v\ (rms) = 0.0156\ m/sec$$

For this measurement we wish to measure peak velocities. From Eqn. III.2.A. & B.6.

$$v\ (rms) = 0.707 \times v\ (peak)$$

$$v\ (peak) = \frac{v\ (rms)}{0.707}$$

$$\therefore\ v\ (peak) = \frac{0.0156}{0.707}$$

$$\therefore\ \underline{v\ (peak) = 0.0221\ m/sec}$$

This value will now be set on the sound level meter. Turn the sound level meter to "Batt." to check the battery and then to Fast or Slow. With the WEIGHTING NETWORK set to "Lin." set the INPUT ATTENUATOR, (black knob) fully clockwise and set the OUTPUT ATTENUATOR, (clear knob) to indicate 10^{-1}. This figure indicates the FULL SCALE METER READING. Thus adjust the GAIN ADJ. potentiometer with a small screwdriver to give a total reading of 0.87 (8.7 on the meter and 10^{-1} on the attenuators). The sound level meter is now calibrated to measure the peak velocity vibration level in m/sec.

Step 6, Accelerometer Mounting: It should be pointed out that the frequency range of accelerometers is very much dependent on the method of mounting the accelerometer. At high frequencies the response curves of most accelerometers show a very high peak due to a resonance inherent in their construction (refer to Figure III.2.A. & B.4). The frequency response is, however, flat up to a certain frequency below the resonance frequency. The accelerometer so far described (B. & K. Type 4339) has a flat frequency response up to approximately 18 KHz and a resonant frequency of approximately 33 KHz (and a resonant frequency of approximately 33 KHz.) This upper frequency limit is however only achieved when the accelerometer is mounted in the best possible way, i.e. using a threaded stud. Shown in Figure III.3.C. & D.3. are various methods of mounting accelerometers. Also given in the table below are the upper frequency limits for each mounting method.

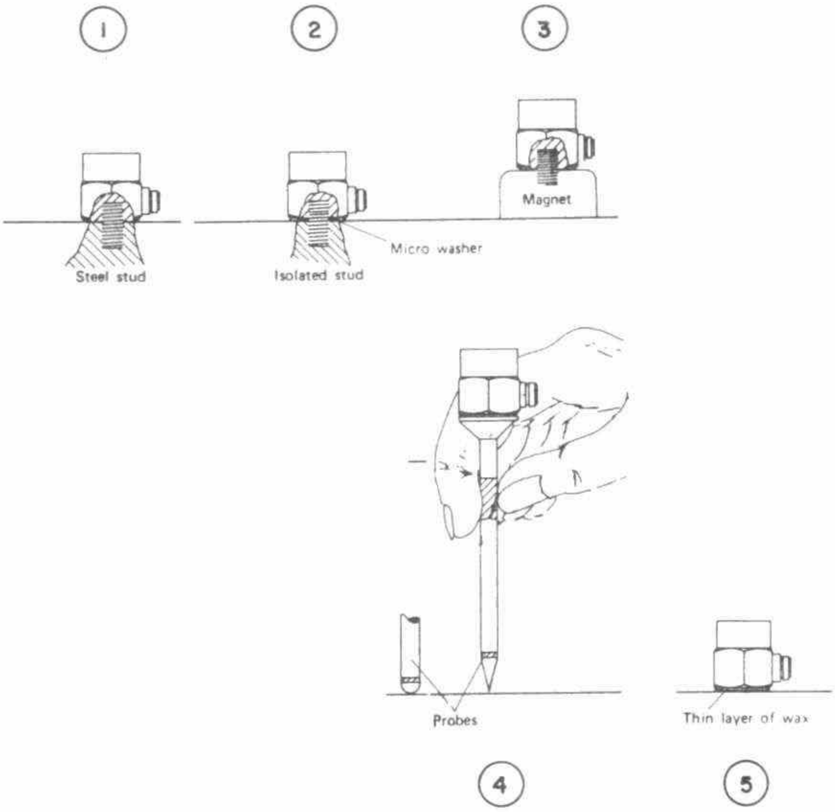


Figure III·3·C & D·3: Different Methods of Mounting the Accelerometer

1. With Steel Stud
2. With Isolated Stud and Mica Washer
3. With Permanent Magnet
4. Handheld with Probe
5. Accelerometer stuck on with wax

Mounting Method Number (referred to the figure)	Upper Frequency Limit (KHz)	Resonant Frequency (KHz)
1	18	33
2	10	26
3	6	10
4	0.5	3
5	10	33

Table 2 : Upper Frequency Limitation for Various Accelerometer Mounting Methods

The lower frequency limit usually depends on the instrumentation used with the accelerometer. In the case of the set-up shown in Figure III.3.C. & D.1., the lower frequency limit is set by the integrator used with the sound level meter. The lower limit for accurate conversion of acceleration to velocity is approximately 20 Hz.

It should be pointed out that the accelerometer will always respond to frequencies outside the ranges we have mentioned. Great care should be taken that frequencies outside these ranges do not dominate the measurement. This particularly applies to very high frequencies which can be greatly amplified by the very high resonance peak of the accelerometer. The method of mounting should thus be chosen to avoid such inaccuracy.

Care should also be taken in mounting the cable at its point of attachment to the accelerometer. If the cable is not properly mounted then a cable "whip" may possibly result, giving an extraneous signal. The correct method of mounting the cable is shown in Figure III.3.C. & D.4.

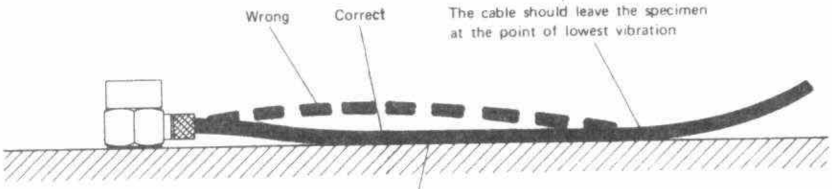


Figure III·3·C & D·4: Clamping of the Cable to Avoid Relative Movements (Cable Whip).

Step 6 - Measurement: The accelerometer should be mounted according to the instructions above. The sound level meter should not be placed on a vibrating surface but placed away from the object whose vibration level is being measured. Only the INPUT and OUTPUT ATTENUATORS need be changed from the settings given in the calibration instructions. Initially set the OUTPUT ATTENUATOR fully clockwise and the INPUT ATTENUATOR to indicate "3.10^{+3}"

1. Turn the INPUT ATTENUATOR progressively clockwise until an on scale meter deflection is obtained. If the INPUT OVERLOAD lamp flashes turn the INPUT ATTENUATOR progressively anti-clockwise until the flashing stops.

2. If no meter deflection is obtained with the INPUT ATTENUATOR fully clockwise, progressively turn the OUTPUT ATTENUATOR anti-clockwise until a meter deflection occurs. If the OUTPUT OVERLOAD lamp flashes then turn the OUTPUT ATTENUATOR progressively clockwise until the flashing stops.

3. Note the attenuator setting, and consider whether it contains a 3×10^N number or a 10^N number. Use this information to read the meter deflection off the correct scale. Remember that the attenuator setting refers to full scale deflection.

4. Combine the meter deflection and the attenuator setting to obtain the vibration velocity in m/sec. Convert to mm/sec if required by multiplying the result by 1000.

The procedure described above measures the peak vibration velocity only in the direction of one axis. In the application to measure the ground vibration covered in the Topic II.3.A., the particle velocity is required in all three mutually perpendicular axes, these axes being vertical, radial (along a horizontal line joining the place of blast to the location of measurement) and the transverse (along a horizontal line at right angles to the line joining the place of blast to the location of measurement). The three velocity components so obtained (also known as the three "orthogonal vectors") can be summed as below to give the total velocity vector.

$$v_{Total} = \sqrt{v_X^2 + v_Y^2 + v_Z^2} \quad \ldots \ldots \quad \text{(III.3.C. \& D.1)}$$

Where, v_X, v_Y and v_Z are the three mutually perpendicular measurements.

III.3.C.& D.2. PEAK PARTICLE VELOCITY FOR INSTANTANEOUS AND INTERMITTENT VIBRATION:

The procedure discussed above applies when the vibration is of continuous type and lasts long enough to prepare and adjust the instruments, as in the case of rotating machinery. In some applications of the Municipal Noise Control By-law the signal may be instantaneous and intermittent. The ground vibration from quarry blasting operations is one such example, where individual events are less than one second duration (typically 25-35 m.sec.). Such short signals do not allow time for the adjustment of the meter.

Further, the frequency response of the instrumentation severely restricts the accuracy of the measurement when the above procedure is followed. One way to handle the signals is to trigger an oscilloscope connected to a transducer with good low frequency response. The signal trace can then be stored on the screen of the oscilloscope and pictured for subsequent analysis.

In actual field work, it is more convenient to record the signal on an FM tape recorder (used because of its excellent frequency response at low frequencies to D.C.) for later analysis in the laboratory. When recording, precautions are essential not to clip the signals of high crest factors.

III.3.C & D.3 EXAMPLES

Vibration acceleration, velocity or displacement have directions as well as magnitude i.e. they are Vector quantities.

(1) A basement floor close to a subway has the following orthoganal vibration levels in terms of RMS velocity measured at the same time.

$V_{vertical_{RMS}} = .04$ ins/sec

$V_{radial_{RMS}} = .02$ ins/sec

$V_{transverse_{RMS}} = .025$ ins/sec

What is total RMS vibration velocity?

Answer: $V_{Total} = \sqrt{(.040)^2 + (.020)^2 + (.025)^2}$

$= .05$ ins/sec RMS →

(2) The floor of an aircraft has the following vibration levels in terms of RMS acceleration in units of 'g'.

$A_{vertical} = .02g$

$A_{longitude} = .015g$

$A_{lateral} = .01g$

What is the magnitude of total vibration acceleration?

Answer: $A_{Total} = \sqrt{.02^2 + .015^2 + .01^2}$

$= A_{Total} = 0.027\ g_{RMS}$ ⟶

(3) A Quarry blast produces vibration in the basement of a nearby residence. Peak vibration velocity levels were:

$V_{vertical\ p} = 2.1$ cm/s

$V_{radial_p} = 1.8$ cm/s i.e. in the horizontal direction from the blast to the house.

$V_{transverse_p} = 0.5$ cm/s i.e. in the horizontal direction at right angles to a line from the blast to the house.

The components all reached their maximum values at the same instant - what was the total "peak particle velocity" of that point on the basement floor?

Answer: $V_{Total_{peak}} = \sqrt{(2.1)^2 + (1.8)^2 + (0.5)^2}$

$= 2.8$ cm/s peak particle velocity ⟶

SUBJECT:

ENVIRONMENTAL ACOUSTICS - III

TOPIC: III.4.A.& B. (Workshop)

OBJECTIVE:

Trainee will be able to:

1. Determine dominant and secondary sources in a multi-source noise situation.

SUBJECT:

ENVIRONMENTAL ACOUSTICS - III

TOPIC: III.4.C.& D.(Acoustics)

OBJECTIVES:

Trainee will be able to:

1. Describe the characteristics of a tone;
2. Explain what may cause tonality;
3. Give examples of tonal sounds;
4. Explain why tonality is important;
5. Explain how tonal connection is arrived at;
6. Outline limitation of tone measurement with full and one-third octave band filters;
7. State the tonality correction used in the Model Municipal Noise Control By-law.

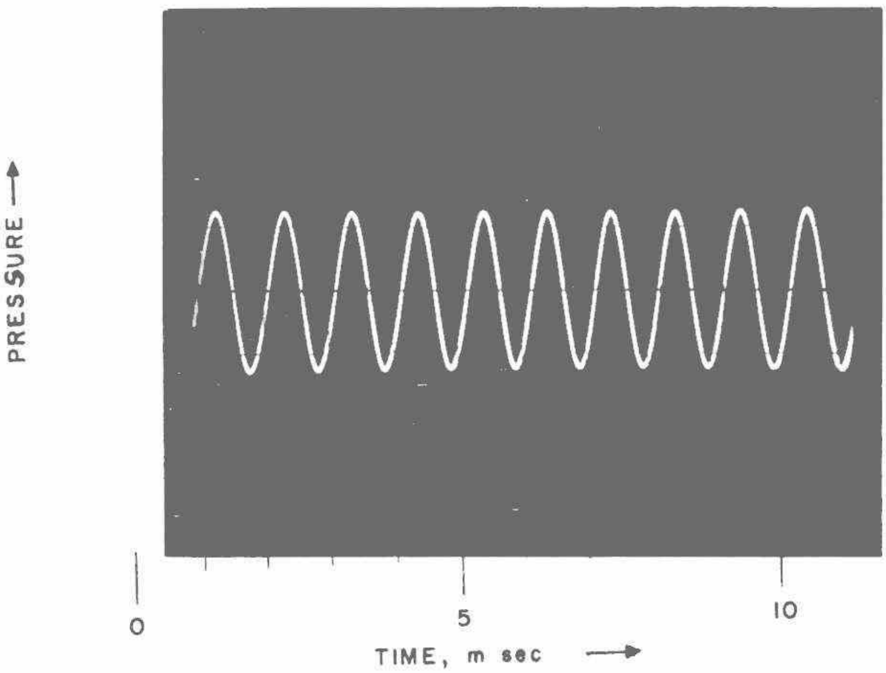
III.4.C.&D.1. DESCRIBE THE CHARACTERISTICS OF TONAL SOUNDS:

A pure tone, such as the tone accompanying the test pattern on a television has a spectrum which is essentially a single spike at one frequency. Looking at the pressure time history of the signal one sees a pure sinusoid (Fig. III.4.C.&D.1) which repeats itself at the frequency of the tone. Many sounds contain one or more tones. For instance, pronouncing a vowel gives a pressure time history rather like a distorted sinusoid. Figure III.4.C.&D.2 shows the pressure time history for the sound "A" as in gate and its frequency spectrum. The spectrum is made up of a single tone and its multiples or harmonics at 150 Hz, 300, 450, etc. These harmonics define the "quality" of the sound. Again, the signal repeats itself at the frequency of the fundamental. Although in some cases, such as fans, the fundamental tone and its harmonics, which are caused by the repeated passage of the fan blades through the air, may be obscured to some extent by the associated rush of air through the fan, the ear and the spectrum may still show up some of the tones.

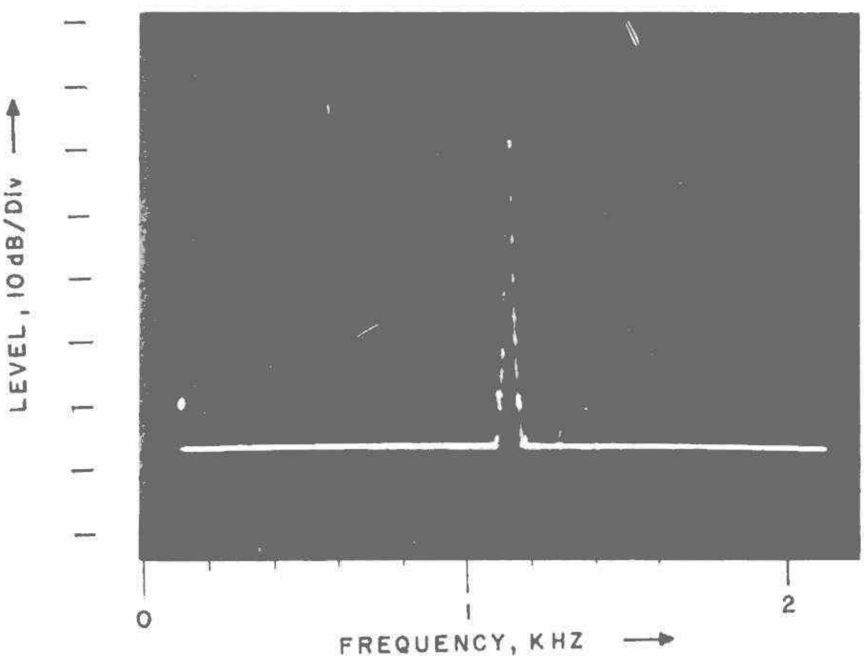
III.4.C.&D.2. EXPLAIN WHAT MAY CAUSE TONALITY:

The one common factor which appears in all the tonal sounds described above is that something is repeating itself regularly. In the voice, the vocal cords vibrate regularly; in a fan the blades pass by regularly. Whenever some component of a noise source has a repeatable motion it is worth checking for tonality. This may sound like a hum, buzz or whine.

Most noises are caused either by a cyclic movement of some kind, by banging, or by moving air. The first type of noise is almost always tonal: e.g. fans and blowers, any motor using rotating or oscillating parts or repeated explosions, any alternating current electrical noise source like a transformer. The second two can excite tonal resonances: e.g. blowing on a pop bottle or tapping a crystal goblet. Banging sounds usually require special treatment and will not be treated further here. Obviously not every source is quite so easy to recognize, but the basic mechanisms remain the same.

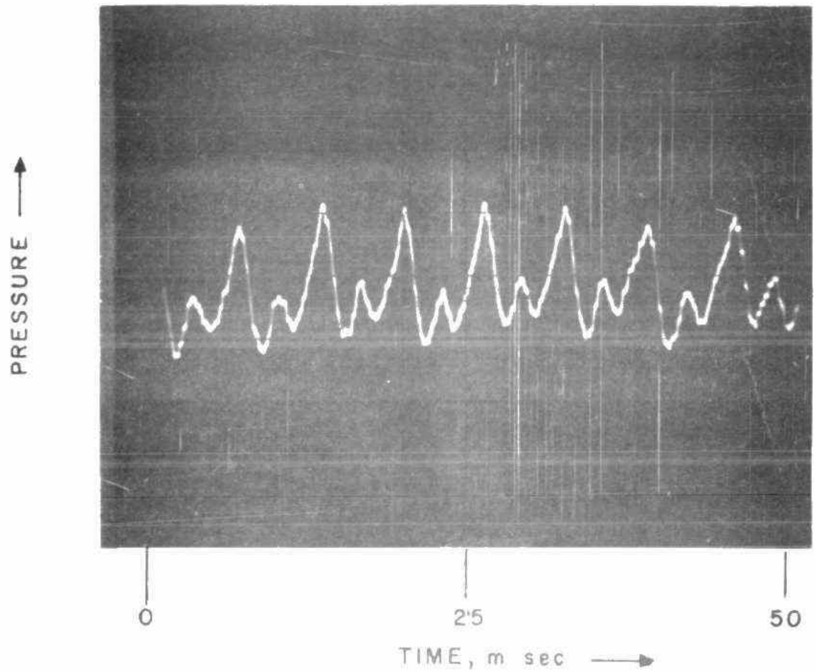


(a) Pressure vs. Time History

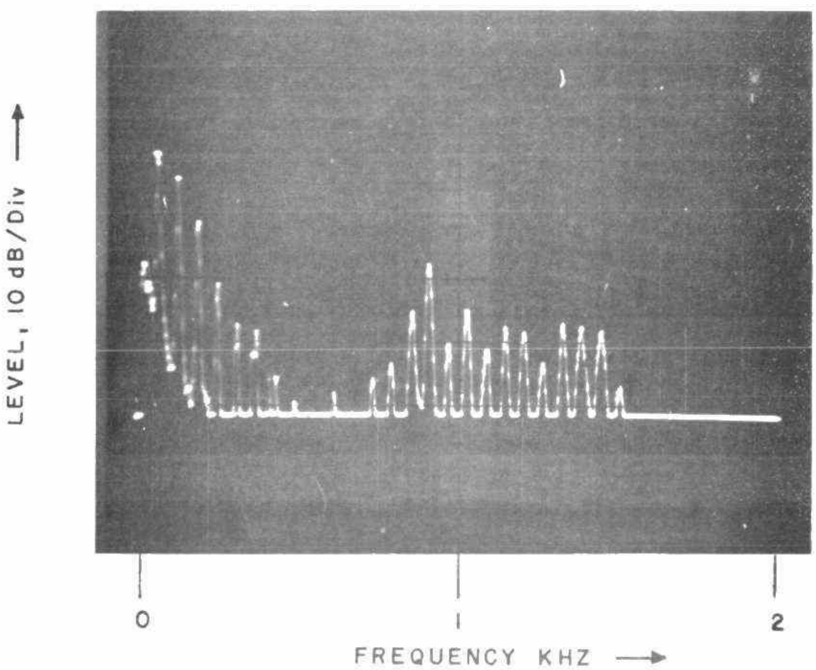


(b) Narrow Band Frequency Spectrum

Figure III.4.C.&D.1: Analysis of a Pure Tone Sinusoid



(a) Pressure vs. Time History



(b) Narrow Band Frequency Spectrum

Figure III.4.C.&D.2: Analysis of Vowel 'A' Sound as in Gate

III.4.C.&D.3. EXAMPLES OF TONAL SOUNDS:

The following examples may help in recognizing tonal sources:

FIGURE	SOUND SOURCE	SUBJECTIVE DESCRIPTION	CAUSES	CHARACTERISTICS
III.4. C.&D.3	Roots Blower	Rasping	Repeated pulses of air	Many important harmonics
III.4. C.&D.4	Gas Lawn Mower	Buzzing	Repeated explosions	Individual explosions obvious in signal
III.4. C.&D.5	Electric Lawn Mower	Whine	Rotation in a bearing & repeated brush noise	Less harmonic content
III.4. C.&D.6	Siren	Screaming	Electronic Signal or repeated bursts of air	Quite pure tones
III.4. C.&D.7	Transformer	Hum or buzz	Motion caused by alternating magnetic field.	120 Hz and harmonics

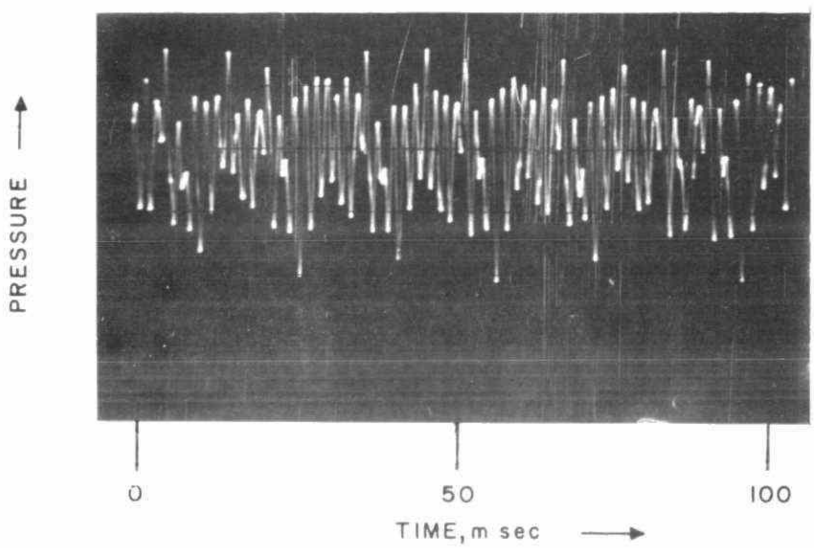
III.4.C.&D.4. EXPLAIN WHY TONALITY IS IMPORTANT:

Sounds with distinct tonal quality are often more annoying than sounds with a smooth spectrum without obvious peaks. It is for this reason that tonal sounds require more detailed analysis, either with octave or 1/3 octave filters.

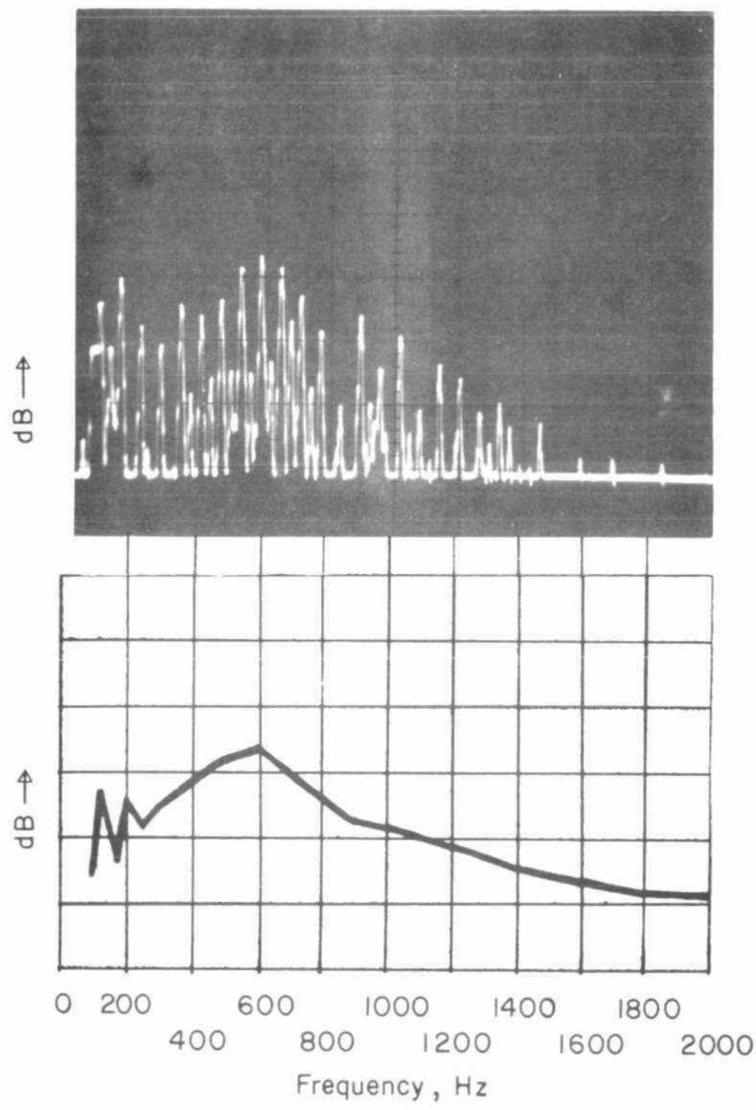
III.4.C.&D.5. TONAL CORRECTIONS:

Although A-weighted sound levels correspond reasonably well to loudness it is consistently found that given two sounds with the same sound levels, the one with a tone in it will sound louder. Sound level readings must be corrected to allow for this effect and bring the measured level in-line with the actual loudness of the sound.

Through various methods, including jury testing, the difference between two sounds with equal sound levels but different degrees of tonality has been measured. This information provides the basis for tonality corrections.



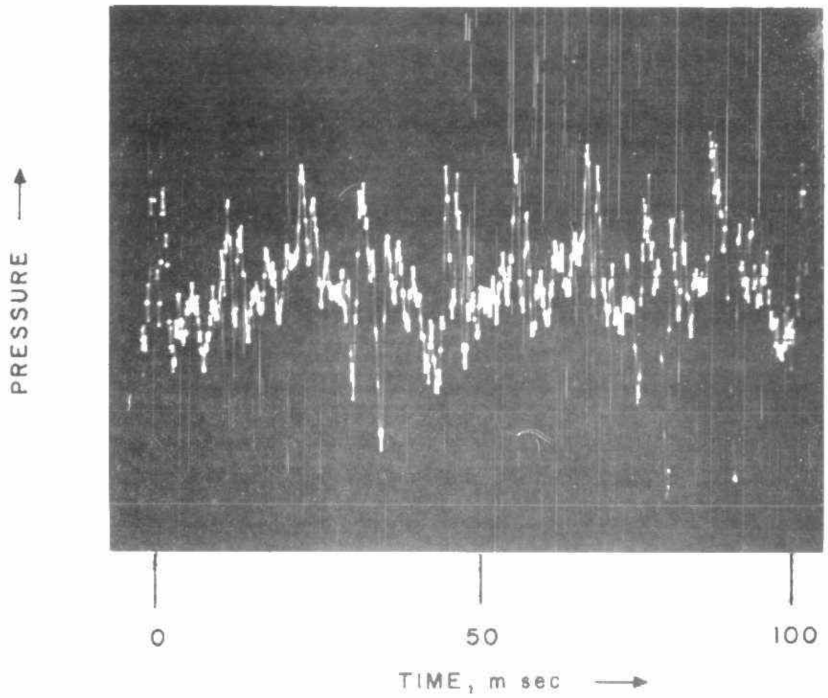
(a) Pressure vs. Time History



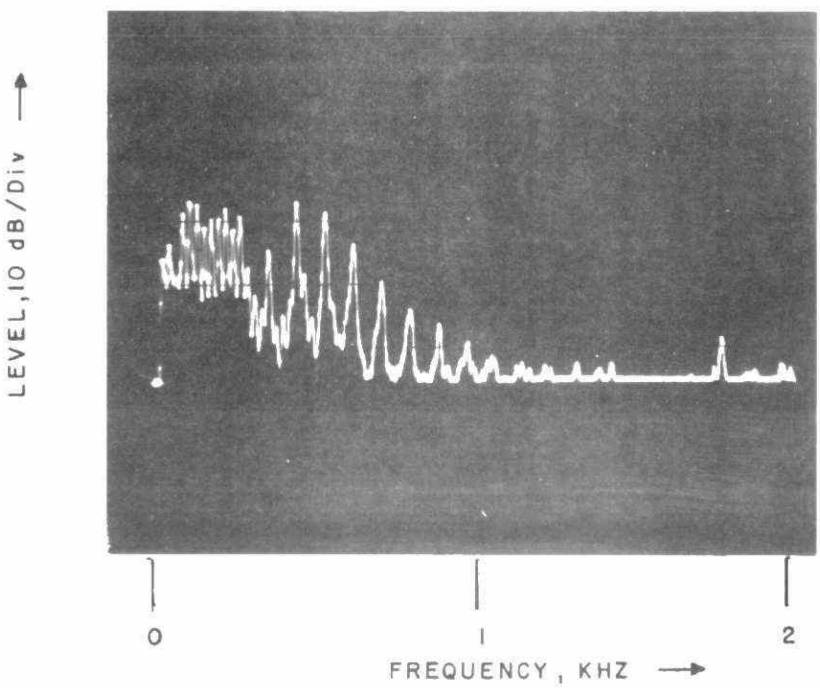
(b) Narrow Band Frequency Spectrum

(c) One-Third Octave Band Frequency Spectrum

Figure III.4.C.&D.3: Analysis of a Roots Blower Sound

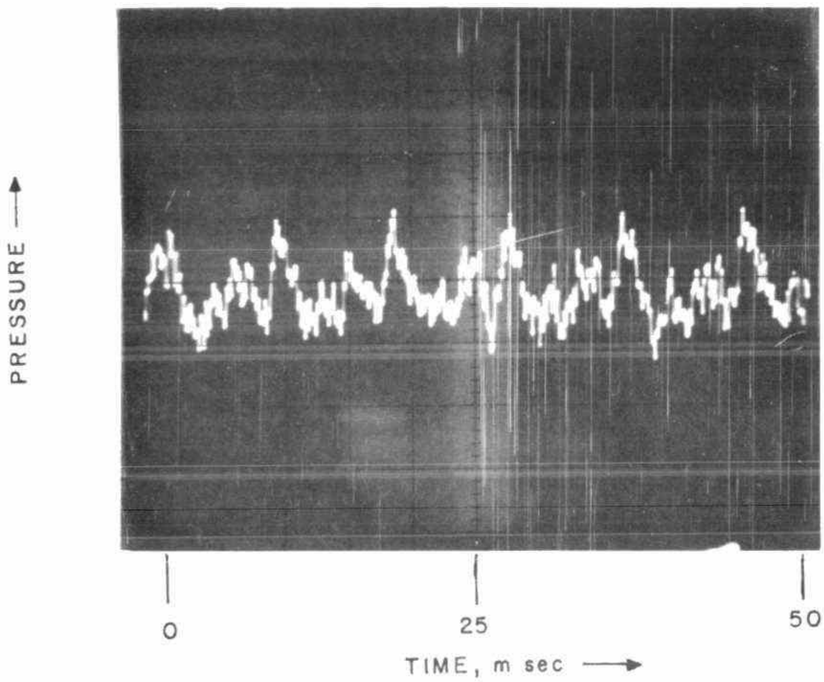


(a) Pressure vs. Time History

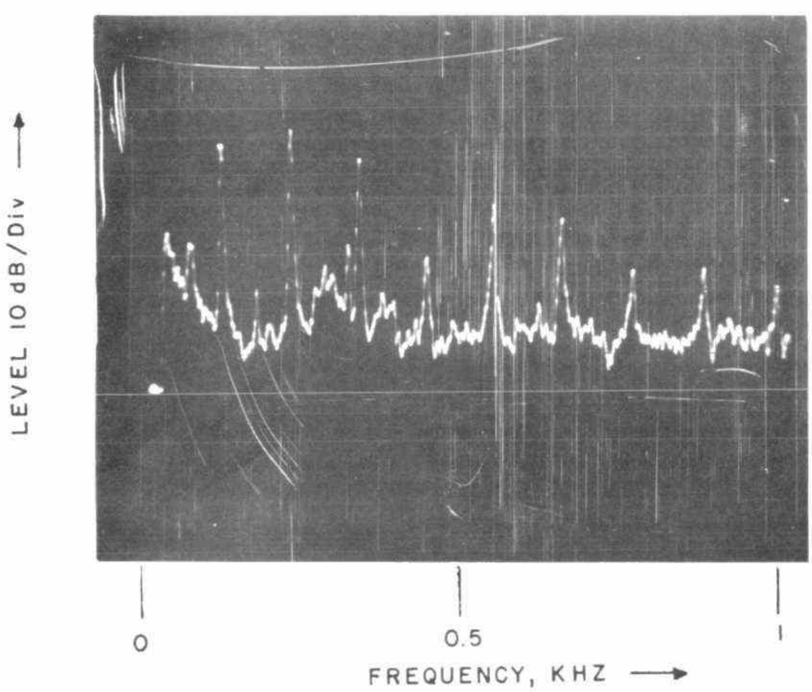


(b) Narrow Band Frequency Spectrum

Figure III.4.C.&D.4: Analysis of a Gas Lawn Mower Sound

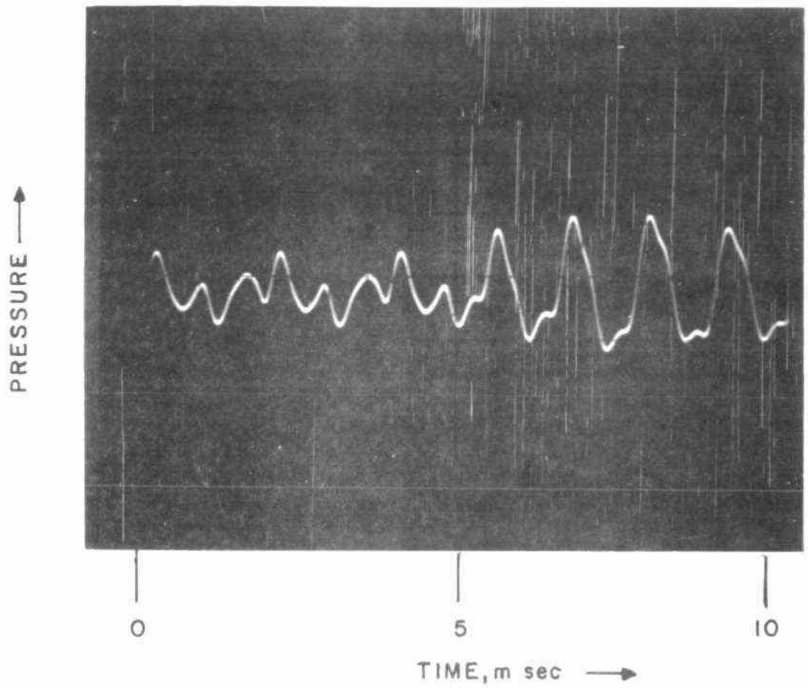


(a) Pressure vs. Time History

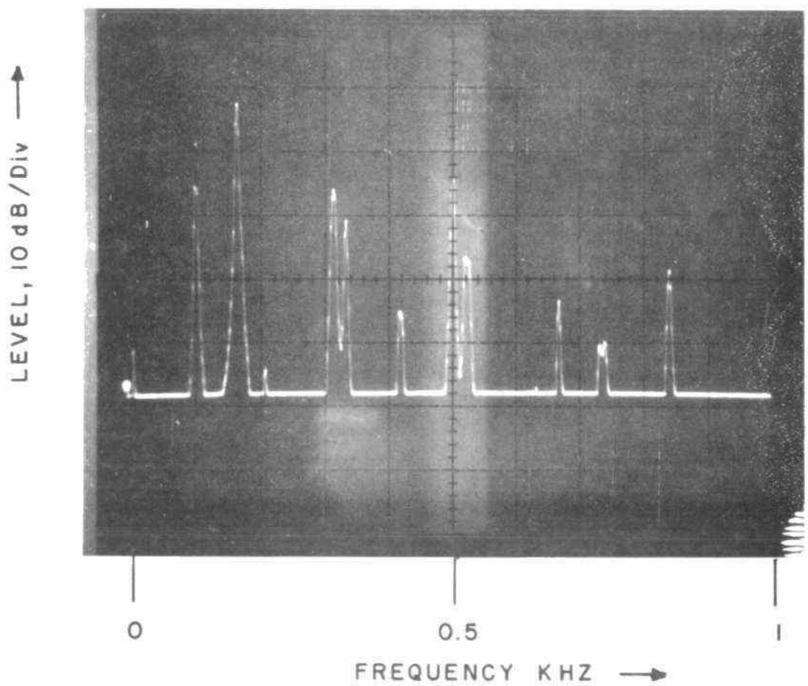


(b) Narrow Band Frequency Sprectrum

Figure III.4.C.&D.5: Analysis of an Electric Lawn Mower Sound

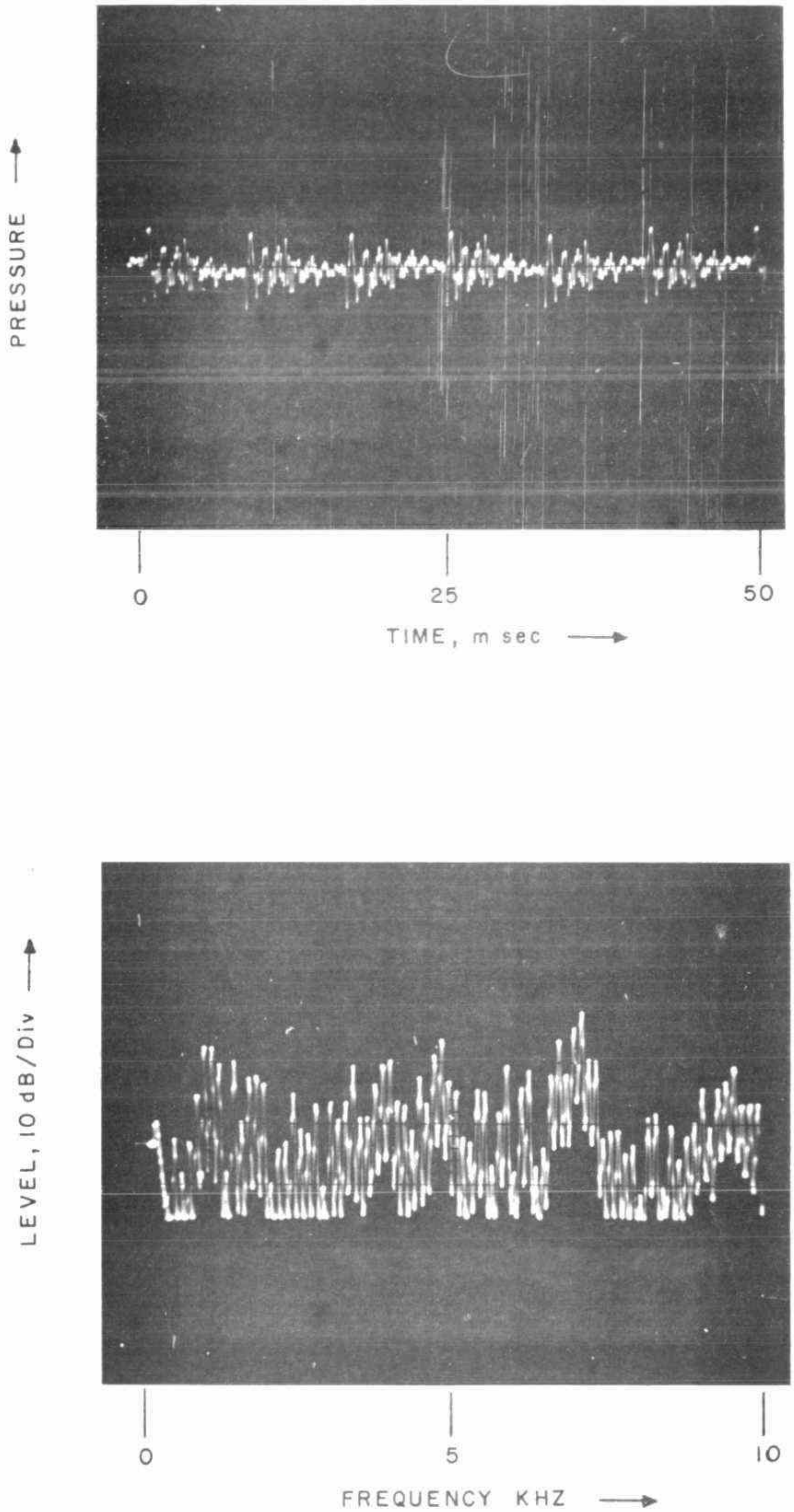


(a) Pressure vs. Time History



(b) Narrow Band Frequency Spectrum

Figure III.4.C.&D.6: Analysis of a Siren Sound



(a) Pressure vs. Time History

(b) Narrow Band Frequency Spectrum

Figure III.4.C.&D.7: Analysis of a Transformer Sound

One of the better known tonality corrections was developed by K.D. Kryter at the Stanford Research Institute. His method provides a good example of the use of a tonality correction.

Kryter's method uses the graph shown in Figure III.4.C.&D.8. Corrections are made to each octave or 1/3 octave band in which a tone is present. The A-weighted tonally corrected sound level is next calculated by logarithmically adding the corrected octave or 1/3 octave band levels.

III.4.C.&D.6. LIMITATION OF TONE MEASUREMENT WITH FULL AND ONE-THIRD OCTAVE FILTERS:

Tonal corrections based on full or 1/3 octave measurements break down in some cases as these filters are just not fine enough. This is demonstrated by Figure III.4.C.&D.3 in which a 1/3 octave band spectrum and the corresponding narrow band spectrum of a roots blower are compared.

The tones corresponding to the harmonics of the fundamental firing frequency are present in each of the 1/3 octave bands as shown in the upper picture resulting from a narrow band frequency analysis. In the lower spectrum produced by 1/3 octave analysis, these spikes are altogether missing.

III.4.C.&D.7. TONALITY CORRECTION USED IN THE MUNICIPAL MODEL NOISE CONTROL BY-LAW

A Ministry study of tonal noise complaints compared tonally corrected A-weighted levels with the original A-weighted level. The difference between the two for most common noise sources appears to be around 5 dB. To simplify the use of the By-law this simpler correction has been adopted, and tonal sounds are qualitatively defined as sounds such as hums, buzzes or whines having a certain identifiable pitch.

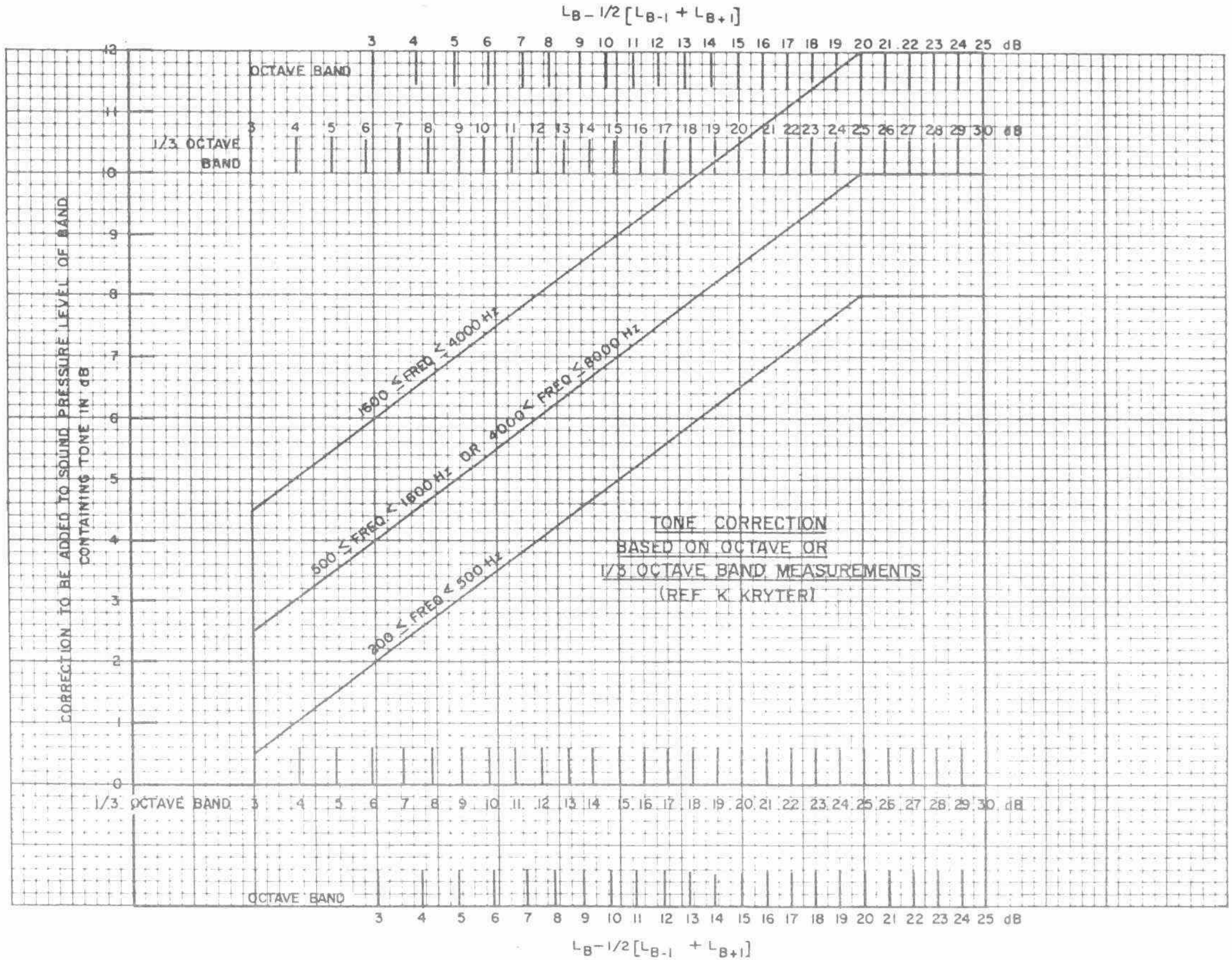


Figure III·4·C & D·3: Kryter's Tonality Corrections

SUBJECT:

ENVIRONMENTAL ACOUSTICS - III

TOPIC: III.5. A.& B. (Review)

OBJECTIVES:

Trainee will be able to:

1. Clarify and improve upon his understanding of the course material covered during Environmental Acoustics - III, to be accomplished through questions and answers during the review session.

SUBJECT:

ENVIRONMENTAL ACOUSTICS - III

TOPIC: III.5.C.& D. (Exam)

OBJECTIVE:

Trainee will be able to:

1. Answer questions related to Acoustics theory, procedures, instrumentation and measurement techniques covered during the course. Record sheets completed by trainee in the workshop periods will also be included as a part of the performance assessment.

III.5.C.& D. EXAMPLE OF EXAMINATION QUESTIONS:

The following groups of examination questions are typical of the scope of the training material covered in the course lectures, the practical workshops and the training manual prepared for the Environmental Acoustic Technology-II Course.

The reader is invited to attempt them at leisure. Staff of the Noise Pollution Control Section are available for consultation should any further assistance be desired.

The Municipal trainee attending the Environmental Acoustics-II Training Course is given 2 weeks to answer a similar exam questionaire. The trainee must attempt a minimum of 3 questions in each group of questions.

Upon satisfactorily completing the Environmental Acoustic Technology-II Course, the Municipal employee is awarded a Class 1 certificate - Noise Control Investigator, valid for 3 years from the date of issue. Completion of the course also entitles the recipient to 1 unspecified credit from the Ontario Association of Certified Engineering Technicians and Technologists (OACETT).

PART A

1. A tape recorded sample of noise was analysed using a B & K Statistical Distribution Analyser. The following is the data:

Channel	Count
1	0
2	0
3	0
4	0
5	7
6	25
7	278
8	356
9	33
10	1
11	0
12	0

The number of seconds per count was 10. Calculate the L_{eq} value (using an L_{eq} calculation sheet) and the measurement duration, if the level recorder paper was calibrated to range from 40 to 90 dBA.

2. The noise output from a machine was monitored for twelve hours and it was then stopped. The results were as follows:

82 dBA	1 hour
79 dBA	2 hours
78 dBA	5 hours
55 dBA	4 hours

Calculate the L_{eq} value for the machine over a twelve hour period.
What is the L_{eq} value for the 24 hour period?

3. The impact of a new Go train service on a residential subdivision was investigated. Noise measurements were taken at the property boundary and the following results were obtained for the period 7 a.m. to 7 p.m.

Accelerating Trains, 5, average speed 20 m.p.h., L_{eq} during period train in front of microphone 86 dBA.

Decelerating Trains, 7, average speed 15 m.p.h., L_{eq} during period train in front of microphone 79 dBA.

Each train consisted of 1 locomotive of length 55 feet and 10 cars of length 60 feet each. Calculate the 12 hour total L_{eq} for the events from 7 a.m. to 7 p.m. using the time/level trade-off relationship for L_{eq}.

4. The general formula for obtaining an L_{eq} value is

$$L_{eq} = 10 \log \frac{1}{T}\int_0^T \left(\frac{p(t)}{p_0}\right)^2 dt.$$

Explain this formula in detail paying particular attention to the concept and implications of energy averaging.

5. The trade-off relationship of time against level for L_{eq} measurements is as follows:

$$L_{eq2} = L_{eq1} - 10 \log\left(\frac{T_2}{T_1}\right)$$

Rearrange this expression to obtain a relationship for ΔL_{eq}, the decrease in L_{eq}, in terms of the time ratio $\left(\frac{T_2}{T_1}\right)$. List a table of ΔL_{eq} against $\left(\frac{T_2}{T_1}\right)$ with $\left(\frac{T_2}{T_1}\right)$ varying from 1 to 10 in steps of 1.

6.(a) Crest factor is defined as the ratio P_{Peak}/P_{RMS}
A sound level meter can accurately measure signals with a crest factor of up to 6. If the maximum RMS sound level it can accurately measure is 95 dBA, what is the maximum peak level dBA it can measure?

(b) A Single impulse sound is fed to a sound level meter. Describe with the aid of diagrams how the meter needle will deflect when the following meter responses are set:-

SLOW FAST IMPULSE IMPULSE HOLD PEAK HOLD

PART B

In answering the questions in this part, consider that your employer is the Municipal Council and that the Noise Control By-law has been adopted by Council and is in force.

1. A resident filed a complaint about the noise from his neighbour's central air conditioner unit. The noise inspector visited the site at 2 p.m. and while on the complainants' property measured 56 dBA with the unit on, and 54 dBA with the unit off. Comment on these levels, and describe the subsequent steps in the investigation to determine if the air conditioner is exceeding the limits of 55 dBA (7a.m. to 7p.m.) and 50 dBA (7p.m. to 7a.m.).

2. People living in a new residential area adjacent to a main rail line have complained about a 50% increase in train movements due to the new commuter train service. Indicate the steps you would follow to investigate this complaint, and briefly explain why. What would be the procedure if the tracks and trains were owned by (a) Ontario Northland Railway, (b) Algoma Central Railway, (c) C.N.?

3. The limits of noise from an industrial site into a residential area between 7p.m. - 7a.m. are recommended to be 55 dBA. The residents complain of the noise from 2 plants located side by side in an industrial complex immediately behind their homes. Measurements show the noise levels to be 57 dBA when plants A & B are operating, and 54 dBA when plant A is operating. Does either plant exceed the permissible level? If so, by how much? What would you suggest that the plants do in terms of noise reduction to meet the required level in the area?

4. Residents living close to an industrial plant have complained of hammering noises at 2a.m. on a hot summer night. The noise inspector assigned to the complaint was aware that the source was in the overhaul garage where the dump trucks are repaired during the night shift. On his way home one late evening, the inspector noticed that the doors to the overhaul bay were open, he then entered the garage and spoke to the mechanic that was producing the hammering sounds. He requested the worker to be more considerate of the neighbours.
Is this the proper way to investigate the complaint? If not, why not? How would you proceed to reduce the noise from this plant if the company was co-operative?

5. An investigation into the noise from a large fan produced the following levels on the Company's property line: 70 dBA and 80 dB linear.

(a) An Octave Band analysis produced the following noise spectrum:

31.5 Hz	70 dB
63 "	80 "
125 "	76 "
250 "	67 "
500 "	61 "
1000 "	55 "
2000 "	47 "
4000 "	44 "
8000 "	38 "
16000 "	36 "

Consider the allowable levels are 65 dBA (day) 60 dBA (evening) and 55 dBA (night), for this source.

(i) What is the significance of the measured dBA and dB Linear readings?

(ii) Comment on the measured dBA and the allowable dBA.

(iii) Plot the measured Octave Band Pressure Level readings on the graph which is provided.

(iv) Describe all the instrumentation used to carry out this determination and the set up.

6. A persistent complaint is received from several different persons concerning a barking dog. Describe your investigation and the resolution of the problem considering these scenarios:

   a) Dog barks continuously during daytime (Outdoors).

   b) Dog barks for short periods throughout the night (Outdoors).

   c) Dog barks continuously (Indoors).

PART C

1. The frequency measurements made near a lathe show that high frequency sound over 12 KHz is present. A set-up, consisting of a B & K 4117 piezoelectric microphone and a Uher tape recorder at 9.5 cm/sec. recording speed, was selected to record this sound for subsequent narrow band analysis in the laboratory. Is this choice of measuring set-up adequate to fully reproduce the entire spectrum? If not, why not? What recommendations will you make to adjust this system to meet the requirement?

2. One-third octave measurements of a fan sound suggest the presence of sound energy within the 90 Hz to 8 KHz range. Tape speed of 9.5 cm/sec (on Uher) was employed to record the sound with the help of a B & K type 2203 sound level meter and a B & K 4117 microphone. Can the tape speed be reduced to 2.4 cm/sec to economise use of the tape, without adversely affecting the measurement quality?

3. When recording a noise signal, the attenuator setting was set at 80 dB. Calibration of the tape was carried out with the help of a B & K 4230 calibrator producing 94 dB. In subsequent analysis of the tape, the attenuator was set at 110 dB, while playing back the calibration tone and the needle deflection was adjusted to +4 dB. When playing back the noise signal, the attenuator setting was 110 dB and, the needle deflection +8 dB. What is the sound pressure level of the recorded signal?

4. The sound pressure level of a noise signal measured at a site is 105 dB. How would you match the sound level meter dynamic range to that of a UHER tape recorder using a B & K 4230 calibrator for tape calibration?

5. What limits the upper and lower frequency response of the tape-recorder?

6. The frequency response of the B & K 2203 sound level meter fitted with a B & K 4117 piezoelectric microphone is 10 Hz - 10 KHz. Using the UHER tape recorder, what tape speed(s) could be selected for tape recording of a noise signal?

PART D

1. If you have the A weighted, 'fast' and 'slow' response readings of an impulse sound, can you calculate the impulse level? Explain.

2. With the help of examples, explain the advantages and disadvantages of "Impulse" and "Impulse Hold" meter responses.

3. Give 5 examples of sounds which, although essentially continuous, require the use of an impulse sound level meter for proper evaluation. Explain.

4. What is IEC 179A? What are the tolerances for the impulse response setting specified in IEC 179A?

5. You are required to measure the A weighted impulse sound level of a drop forge. Outline the complete measurement procedure using the sound level meter of your choice, from the initial set-up to the final calibration. (ignore the microphone installation procedure).

6. In the training course you have learned that when using linear or flat weighting; subaudible (low frequency) pressure fluctuations can interfere with your meter readings. What is the major outdoor source of this type of pressure fluctuation? Explain how the interference is caused.

PART E

1. A man always works a regular eight hour day at 90 dBA. Occasionally he must enter an area exposed to 110 dBA. How long will the Industrial Safety Act permit him to work in this area? Explain. How is his schedule affected if he must spend 1 hour daily in the 110 dBA area?

2. A child finds the sound of a dentist's drill quite discomforting. The dentist is not at all bothered by it. Describe three factors which could be causing this difference of opinion.

3. If a person had a severe hearing loss, but a tuning fork placed on his skull could be quite easily heard, where is his hearing problem most likely to be?

4. If an audiogram shows a 25 dB shift at 4000 Hz but the sound at the subject's job is 85 dBA, which is below the Industrial Safety Act levels, what would you suspect is causing the hearing loss? What recommendations would you make?

5. Figure 1 shows the sound spectrum of a snow mobile travelling at 20 mph taken at 15' under full acceleration. What would you expect the audiogram of a trapper, who rides this machine regularly, to look like?

6. A passenger in a light aircraft notices his ears popping. Later, on the ground, he finds they are ringing. Are these effects related? Explain them?

PART F

1. What is the difference between an acoustical measurement standard and sound level limits? Why are these necessary? Answer briefly.

2. What type of SLM's would you use when investigating the following sources of noise. Explain the reasons for the choice for sources (a) and (c).
   a) air conditioner
   b) pavement breaker
   c) quarry blast
   d) portable compressor
   e) bulldozer

3. After proper noise zone mapping, the levels set for a particular area are higher than the level limits for air conditioning. Which takes precedence? Is the reverse true?

4. The noise level of a source is 80 dBA at 25 ft. Without the source, the ambient level was 75 dBA at the same location. What is the correct level of the source alone? Solve this problem in 2 ways.

   (a) using Fig. II.3.A.1. in your course manual
   (b) subtracting the ambient energy from the total energy.

5. Explain briefly the term "overpressure". When measuring overpressure due to a quarry blast is the SLM set to:

   a) fast response
   b) slow response
   c) impulse response
   d) peak response
   e) 'A' weighting
   f) linear
   g) other

   Explain your choice.

6. When monitoring a blast overpressure using the B & K 2209 SLM for enforcement purposes. What is the lowest attenuator setting to be used to ensure that the measurement is meaningful. Explain.

PART G

1. The Environmental Protection Amendment Act, 1974 (no.2) gives the Municipality specific powers that are fundamental in writing a noise by-law. Quote them.

2. What five noise situations fall outside the jurisdiction of a Municipal noise by-law approved and adopted under the EPA?

3.(a) What schedule of information is mandatory in every noise by-law drafted under the EPA? Why?

   (b) What schedule of information is mandatory in every noise by-law of purely qualitative nature drafted under the EPA? Why?

4. What schedule of information is mandatory in every noise by-law incorporating clauses relating to maximum permissible noise levels at points of reception in residential areas. How was this information developed and formulated?

5. Is there a parallel procedure in the Model By-law to the EPA Control Order? Name it and describe how the Municipal procedure can give the same result as the EPA Control Order.

6. Why is Regulation 15, Section 6, of the EPA important to noise control enforcement? Quote the relevant provisions.

PART H

1. Sounds which require Impulse measurement techniques will register a reading on any sound level meter. However, the readings taken may be incorrect. What precautions have been designed into an Impulse sound level meter to allow the user to be sure the readings taken are correct?

2. Impulse sound sources can usually be categorized into 2 large general groups; percussive or impact sounds, and sharp air pulsations. Give 5 common examples in each category. Do not use the examples listed in more than one category.

3. You have been requested to monitor a quarry blast peak overpressure on the linear weighting. There will be only one chance to measure this blast. You have your choice of equipment between the G.R. and B & K sound level meters. List the equipment you would choose and the settings you would select along with the reasons for your choice.

4. Can "Impulse hold" be used to measure sound in high background noise areas? Why?

5. Explain briefly the concept of "the total vector sum" as mentioned in the manual on Ground Vibration level due to a quarry blast.

6. The peak ground vibration velocity components due to a quarry blast were measured to be 25 mm/sec., 26 mm/sec and 20 mm/sec respectively along 3 mutually perpendicular directions. Does the resultant vector sum exceed the level suggested in the model by-law?

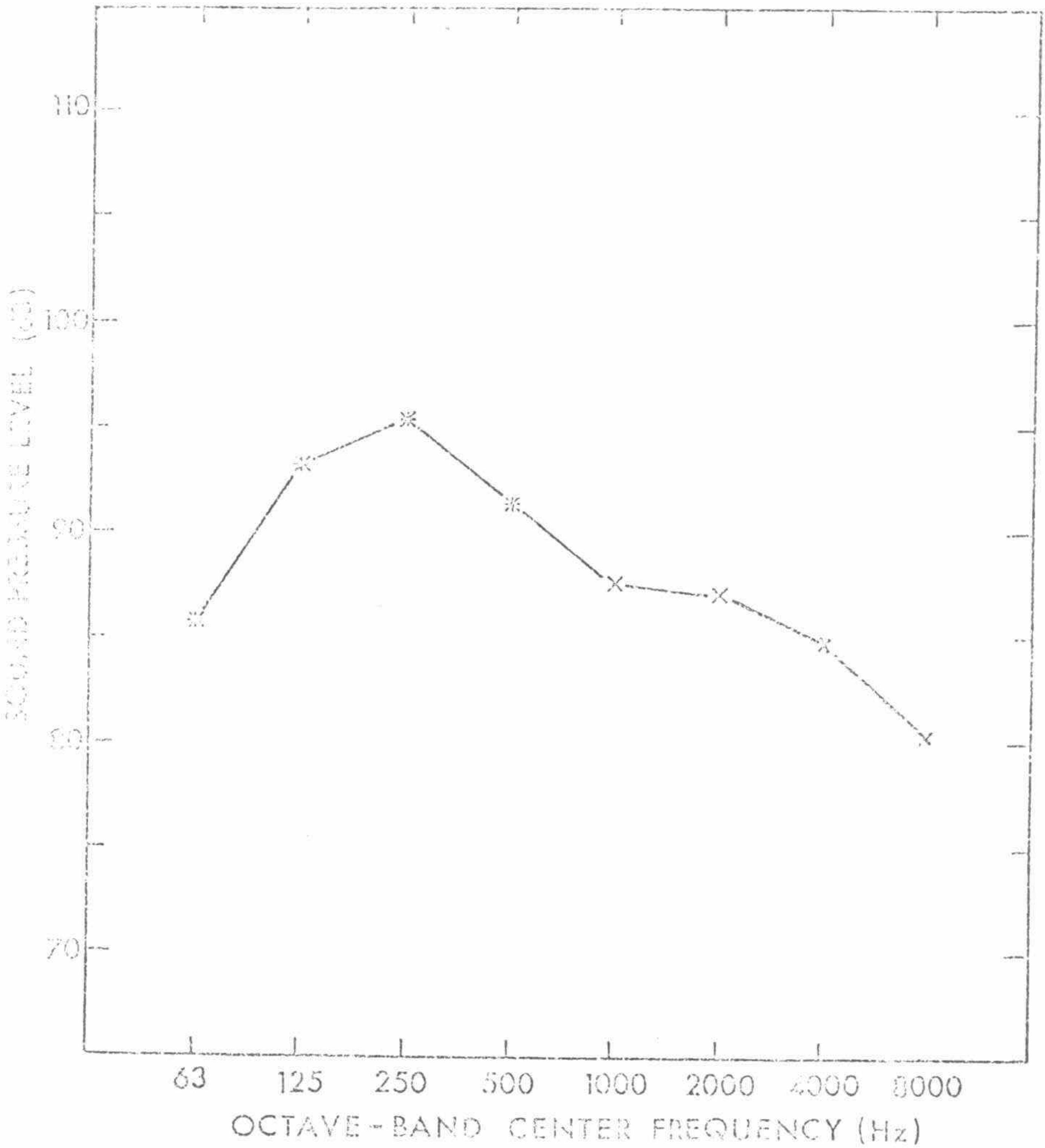


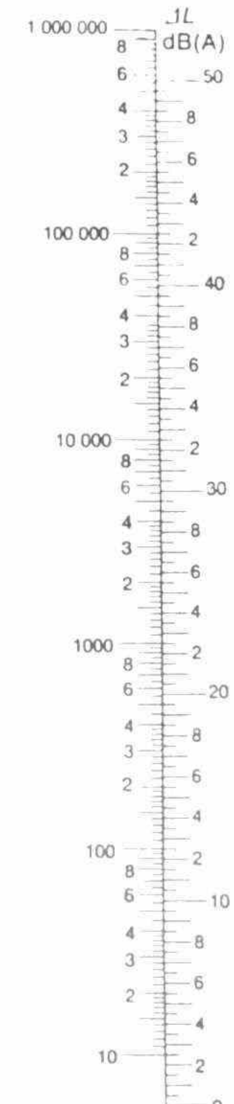
Figure 1 Octave-band analysis of the noise generated by a representative snowmobile (one-cylinder, 333 c.c. displacement, 18 H.P.)

All measurements taken 15 feet to the right of the snowmobile accelerating under full throttle at - 20 m.p.h.

Level Class	0 5	5 10	10 15	15 20	20 25	25 30	30 35	35 40	40 45	45 50
Counter No.	2	3	4	5	6	7	8	9	10	11
Class Time (%)					PARTIAL INDICES					
0.00	0	0	0	0	0	0	0	0	0	0
0.10	0	0	0	0	1	3	10	32	100	315
0.12	0	0	0	0	1	4	12	38	120	380
0.14	0	0	0	0	1	4	14	44	140	445
0.16	0	0	0	1	2	5	16	51	160	505
0.18	0	0	0	1	2	6	18	57	180	570
0.20	0	0	0	1	2	6	20	63	200	630
0.25	0	0	0	1	3	8	25	79	250	790
0.30	0	0	0	1	3	10	30	95	300	950
0.35	0	0	0	1	4	11	35	111	350	1110
0.40	0	0	0	1	4	13	40	127	400	1270
0.45	0	0	0	1	5	14	45	142	450	1420
0.50	0	0	1	2	5	16	50	158	500	1580
0.60	0	0	1	2	6	19	60	190	600	1900
0.70	0	0	1	2	7	22	70	222	700	2220
0.80	0	0	1	3	8	25	80	253	800	2530
0.90	0	0	1	3	9	29	90	285	900	2850
1.00	0	0	1	3	10	32	100	316	1000	3160
1.2	0	0	1	4	12	38	120	380	1200	3790
1.4	0	0	1	4	14	44	140	445	1400	4430
1.6	0	1	2	5	16	51	160	505	1600	5060
1.8	0	1	2	6	18	57	180	570	1800	5700
2.0	0	1	2	6	20	63	200	630	2000	6330
2.5	0	1	3	8	25	79	250	790	2500	7910
3.0	0	1	3	10	30	95	300	950	3000	9500
3.5	0	1	4	11	35	111	350	1110	3500	11 100
4.0	0	1	4	13	40	127	400	1270	4000	12 700
4.5	0	1	5	14	45	142	450	1420	4500	14 200
5.0	1	2	5	16	50	158	500	1580	5000	15 800
6.0	1	2	6	19	60	190	600	1900	6000	19 000
7.0	1	2	7	22	70	222	700	2220	7000	22 200
8.0	1	3	8	25	80	253	800	2530	8000	25 300
9.0	1	3	9	29	90	285	900	2850	9000	28 500
10.0	1	3	10	32	100	316	1000	3160	10 000	31 600
12	1	4	12	38	120	380	1200	3790	12 000	37 900
14	1	4	14	44	140	445	1400	4430	14 000	44 300
16	2	5	16	51	160	505	1600	5060	16 000	50 600
18	2	6	18	57	180	570	1800	5700	18 000	57 000
20	2	6	20	63	200	630	2000	6330	20 000	63 300
25	3	8	25	79	250	790	2500	7910	25 000	79 100
30	3	10	30	95	300	950	3000	9500	30 000	95 000
35	4	11	35	111	350	1110	3500	11 100	35 000	111 000
40	4	13	40	127	400	1270	4000	12 700	40 000	127 000
45	5	14	45	142	450	1420	4500	14 200	45 000	142 000
50	5	16	50	158	500	1580	5000	15 800	50 000	158 000
60	6	19	60	190	600	1900	6000	19 000	60 000	190 000
70	7	22	70	222	700	2220	7000	22 200	70 000	222 000
80	8	25	80	253	800	2530	8000	25 300	80 000	253 000
90	9	29	90	285	900	2850	9000	28 500	90 000	285 000
100	10	32	100	316	1000	3160	10 000	31 600	100 000	316 000

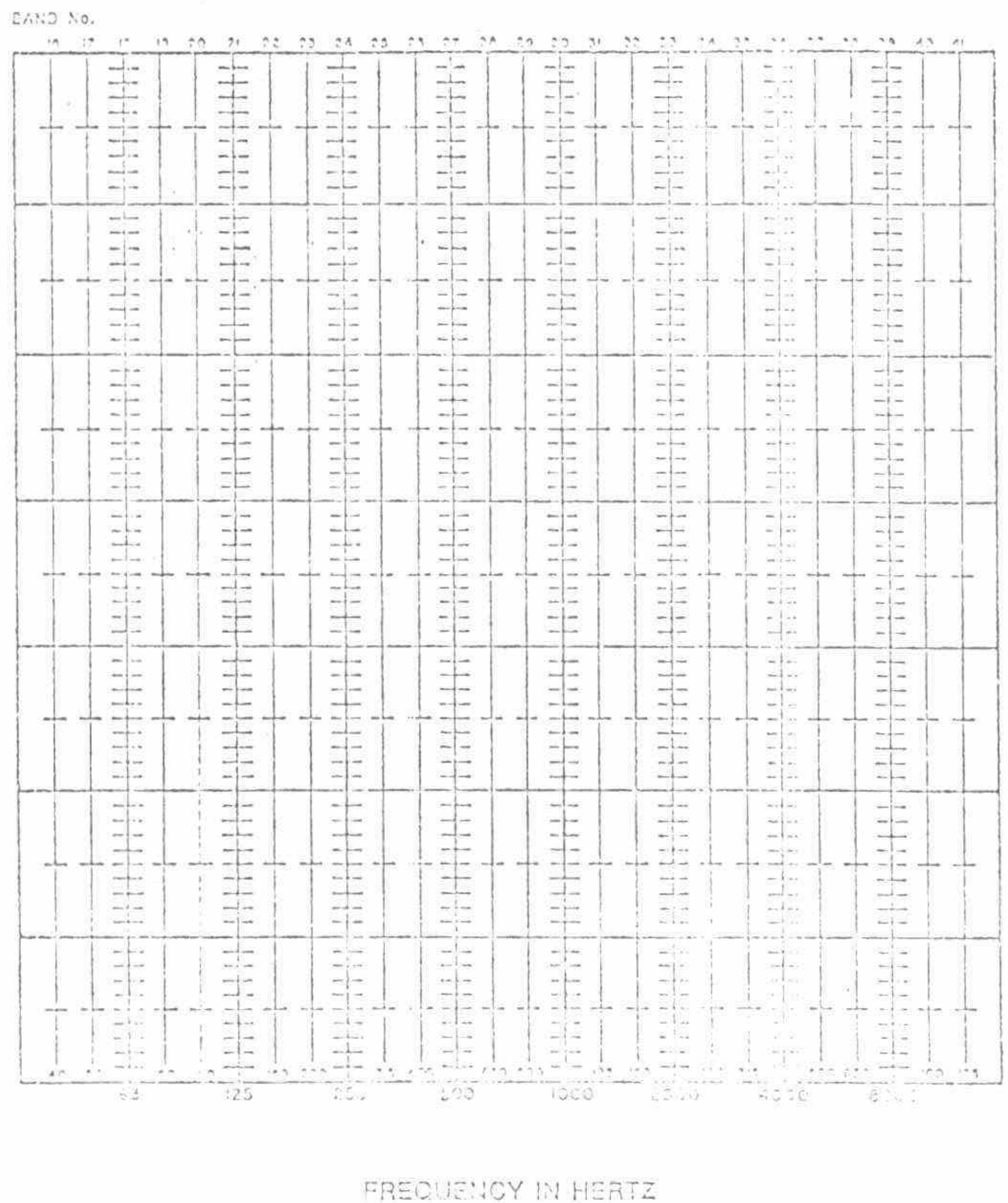
< 0	> 50	dB(A) + L_o dB(A)
1	12	Note Counter + Readings

Count No	Counter Reading	Class Time (%)	Partial Index
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
SUM			



$$L_{eq} = L_o + \Delta L$$

L_o = dB(A)
ΔL = dB(A)
L_{eq} = dB(A)



LEGEND

GRAPH TITLE

GRAPH NUMBER

DATE

Number	Log	Number	Log	Number	Log	Number	Log
1.0	0.00	4.0	0.60	7.0	0.85	1	0
						10	1
1.1	0.04	4.1	0.61	7.1	0.85	100	2
1.2	0.08	4.2	0.62	7.2	0.86	1000	3
1.3	0.11	4.3	0.63	7.3	0.86	10000	4
1.4	0.15	4.4	0.64	7.4	0.87	100000	5
1.5	0.18	4.5	0.65	7.5	0.88	1000000	6
1.6	0.20	4.6	0.66	7.6	0.88	etc.	
1.7	0.23	4.7	0.67	7.7	0.89		
1.8	0.26	4.8	0.68	7.8	0.89	10^0	0
1.9	0.28	4.9	0.69	7.9	0.90	10^1	1
						10^2	2
2.0	0.30	5.0	0.70	8.0	0.90	10^3	3
						10^4	4
2.1	0.32	5.1	0.71	8.1	0.91	10^5	5
2.2	0.34	5.2	0.72	8.2	0.91	10^6	6
2.3	0.36	5.3	0.72	8.3	0.92	etc.	
2.4	0.38	5.4	0.73	8.4	0.92		
2.5	0.40	5.5	0.74	8.5	0.93		
2.6	0.41	5.6	0.75	8.6	0.93		
2.7	0.43	5.7	0.76	8.7	0.94		
2.8	0.45	5.8	0.76	8.8	0.94		
2.9	0.46	5.9	0.77	8.9	0.95		
3.0	0.48	6.0	0.78	9.0	0.95		
3.1	0.49	6.1	0.79	9.1	0.96		
3.2	0.51	6.2	0.79	9.2	0.96		
3.3	0.52	6.3	0.80	9.3	0.97		
3.4	0.53	6.4	0.81	9.4	0.97		
3.5	0.54	6.5	0.81	9.5	0.98		
3.6	0.56	6.6	0.82	9.6	0.98		
3.7	0.57	6.7	0.83	9.7	0.99		
3.8	0.58	6.8	0.83	9.8	0.99		
3.9	0.59	6.9	0.84	9.9	1.00		

Table of Logarithms

Log	Number	Log	Number	Log	Number	Log	Number
0.00	1.0	0.60	4.0	0.85	7.0	0	1
						1	10
0.04	1.1	0.61	4.1	0.85	7.1	2	100
0.08	1.2	0.62	4.2	0.86	7.2	3	1000
0.11	1.3	0.63	4.3	0.86	7.3	4	10000
0.15	1.4	0.64	4.4	0.87	7.4	5	100000
0.18	1.5	0.65	4.5	0.88	7.5	6	1000000
0.20	1.6	0.66	4.6	0.88	7.6		
0.23	1.7	0.67	4.7	0.89	7.7		
0.26	1.8	0.68	4.8	0.89	7.8	0	10^0
0.28	1.9	0.69	4.9	0.90	7.9	1	10^1
						2	10^2
0.30	2.0	0.70	5.0	0.90	8.0	3	10^3
						4	10^4
0.32	2.1	0.71	5.1	0.91	8.1	5	10^5
0.34	2.2	0.72	5.2	0.91	8.2	6	10^6
0.36	2.3	0.72	5.3	0.92	8.3		etc.
0.38	2.4	0.73	5.4	0.92	8.4		
0.40	2.5	0.74	5.5	0.93	8.5		
0.41	2.6	0.75	5.6	0.93	8.6		
0.43	2.7	0.76	5.7	0.94	8.7		
0.45	2.8	0.76	5.8	0.94	8.8		
0.46	2.9	0.77	5.9	0.95	8.9		
0.48	3.0	0.78	6.0	0.95	9.0		
0.49	3.1	0.79	6.1	0.96	9.1		
0.51	3.2	0.79	6.2	0.96	9.2		
0.52	3.3	0.80	6.3	0.97	9.3		
0.53	3.4	0.81	6.4	0.97	9.4		
0.54	3.5	0.81	6.5	0.98	9.5		
0.56	3.6	0.82	6.6	0.98	9.6		
0.57	3.7	0.83	6.7	0.99	9.7		
0.58	3.8	0.83	6.8	0.99	9.8		
0.59	3.9	0.84	6.9	1.00	9.9		

Table of Antilogarithms

Other Publications of the Ministry of the Environment

- Model Municipal Noise Control By-Law
- Noise Pollution Control Publications
- Training Manuals
  - Environmental Acoustics Technology, I to III
  - Acoustics Technology in Land Use Planning
    - Volumes I and II

Point of Sale

- All publications

  for sale at the:

  Ontario Government Bookstore
  880 Bay Street
  Toronto, Ontario

- The publications may also be ordered from:

  The Publications Centre
  Ministry of Government Services
  880 Bay Street, 5th Floor
  Toronto, Ontario
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